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TRANSIT OF VENUS, 1882.

REPORT of the COMMITTEE appointed by the BRITISH GOVERNMENT to superintend the Arrangements to be made for the sending of Expeditions at the Government expense, and securing co-operation with the Government Expeditions for the OBSERVATION of the TRANSIT of VENUS, 1882 December 6.

A Committee was appointed by the Royal Society in 1881 for the purpose of advising the Treasury and the Admiralty with respect to the conduct of the Transit of Venus Observations in 1882. Their Report was printed as a Parliamentary Paper in October 1881.

The Committee of recommendation considered it undesirable to undertake photographic observations of the transit with the instruments and methods which had been adopted in 1874, and that the time at disposal before the date of the transit was insufficient to allow experiments to be undertaken of methods which might promise greater chance of success, and the construction of any instruments which might be found necessary to carry out such observations, and recommended that attention should be chiefly directed to "contact" observations.

The adoption of this method would also render available valuable co-operation on the part of the numerous experienced and well-equipped observers, both amateur and professional, who were scattered over Australia, New Zealand, Canada, Cape of Good Hope, and Mauritius, all of which Colonies afforded most important stations for the observation of the contacts for the purpose of determining the Sun's distance.

It would therefore only be necessary to send out expeditions to a small number of stations, which were otherwise insufficiently provided for, in order to secure, if the atmospheric conditions were generally favourable, a number of contacts sufficiently great to allow of a value of the Sun's distance, with some pretensions to precision, to be thus obtained.

An Executive Committee was appointed by the Government in 1881 to carry out these recommendations.

The following stations were occupied by expeditions sent directly from England :—

Jamaica,
Barbados,
Bermuda,
Montagu Road, Cape of Good Hope,
Madagascar,
New Zealand,
Brisbane,

and an additional equatoreal was sent to the Cape Observatory, and two equatoreals for the equipment of a station at Aberdeen Road, Cape of Good Hope, for which observers were supplied from the staff at the Royal Observatory, Cape of Good Hope.

The observations at all of these stations were successful, with the exception of Brisbane, where the observations were rendered impossible by dense cloud and rain; and the observations at these stations were supplemented by observations at—

Natal,
Mauritius,
Australia,
New Zealand, and
Canada,

which have been directly forwarded to the Committee, and discussed in the following Report.

A "Draft of Instructions for the Observers" was issued by the British Executive Committee for consideration and discussion in October 1881. This draft was taken into consideration at an International Conference held in Paris in October 1881, and a set of instructions substantially founded upon it was issued, which it was hoped might secure uniformity in the observations. These instructions were supplemented by a set of instructions issued by the British Committee, which were freely distributed in the Colonies, and observers who were provided with instruments of sufficient power to enable them to take a part in the observations with any reasonable prospect of success were invited to co-operate.

In framing these "instructions" it was considered that the chief difficulties to be feared in attempts to deduce an accurate value of the Sun's distance from contact

observations were those connected with the possibility that the recorded times for internal contact might refer to phases which take place with different angles of separation of the limbs; and it was expected that by directing the attention of observers to this difficulty, and by securing, if possible, a considerable number of observations, the mean phases observed for "transit accelerated" would be sensibly the same as that for "transit retarded," which is all that is required for the determination of an exact value of the Sun's distance from a discussion of such contact observations.

It will be seen from the results obtained that these expectations have to a great extent been realised.

Personnel.

The British expeditions sent out from England consisted of the following:—

To *Jamaica*.—R. Copeland, Ph.D., Chief.
Capt. Mackinlay, R.A.

Bermuda.—J. I. Plummer, M.A., Chief.
Lieut. Neate, R.N.

Barbados.—C. G. Talmage, Chief.
Lieut. Thomson, R.A.

Montagu Road, Cape Colony.—A. Marth, Chief.
C. M. Stevens (joined from Cape Civil Service).

Madagascar.—Rev. S. J. Perry, F.R.S., Chief.
Rev. W. Sidgreaves.
W. Carlisle, Assistant.

New Zealand.—Lieut.-Col. G. L. Tupman, R.M.A., Chief.
Lieut. Coke, R.N.

Brisbane.—Capt. Morris, R.E., Chief.
Capt. Darwin, R.E. (who returned viâ Singapore, and connected the station at Port Darwin with Singapore for the determination of the differences of longitude between Greenwich and the Australian stations).
C. E. Peek, F.R.G.S. (who provided his own instruments).

An assistant selected from the corps of the Royal Marine Artillery was attached to each of these expeditions, with the exception of that to Madagascar.

Longitude Determinations in connexion with the Work.

To carry out the work undertaken in a satisfactory manner, it was desirable to obtain a telegraphic determination of the differences in longitude between the Australian stations, the New Zealand stations, and Greenwich. Such determinations had long been a desideratum in science, but difficulties had been experienced in obtaining a skilled observer and instruments for the determination of the difference in longitude between Singapore and an Australian station, which was required to complete the chain of determinations which had already been made. It was therefore arranged that Capt. L. Darwin, R.E., one of the observers attached to the expedition to Brisbane, should return by Singapore and make the necessary observations there, and interchange signals with an Australian observer at Port Darwin. This work was carried out; and the completion of the determination of the differences in longitude between the Australian stations and Greenwich is one of the most valuable indirect results which have been obtained through these expeditions.

The longitude of the station, Nos Vey, in Madagascar, was determined by Capt. Aldrich, R.N., H.M.S. "Fawn," from chronometer runs between the Royal Observatory, Cape of Good Hope, Natal, and Madagascar.

A large number of chronometers, independent of those usually carried by Her Majesty's surveying ships, were added to the equipment of the expedition to Madagascar for this purpose.

The longitude of Bermuda was determined by chronometer runs between Bermuda and New York. The work was carried out by Lieut. Neate, R.N., the errors of the chronometer at New York being supplied from the Observatory at Washington, whose difference of longitude from Greenwich had already been telegraphically determined; the errors of the chronometers at Bermuda were determined by the observers of the expedition.

The Committee have to express their thanks to the Superintendent of the Washington Naval Observatory and the Directors of the Telegraph Lines from Washington

to New York, for the assistance rendered in the determination of the longitude of Bermuda.

The longitudes of the stations selected by Capt. Wharton, "Straight Arm Station" and "Sandy Hill," Straits of Magellan, were connected by him with the station occupied by the German expedition at Punta Arenas (Sandy Point) whose longitude has been determined by Prof. Auwers, and the result communicated to the Committee.

The longitudes of the other stations had either previously been determined by telegraphic communication, or were connected by the observers with stations whose longitude had previously been so determined.

The Committee have to express their great obligations to the Colonial Governments of Canada, Victoria, New South Wales, South Australia, Queensland, New Zealand, Mauritius, Natal, and the Cape of Good Hope for the assistance rendered to the expeditions sent from this country, and for the equipment of Colonial observers who have taken an important part in the observations. The Committee have also been greatly indebted to Earl Crawford, Mr. Barclay of Leyton, and Col. Tomline of Ipswich, for arrangements which rendered it possible for the Committee to secure the assistance of Dr. Copeland, Mr. Talmage, and Mr. Plummer, who took charge of the expeditions to Jamaica, Barbados, and Bermuda respectively; and their thanks are also due to the various telegraph companies for facilities afforded during the progress of the work.

The instruments used by Dr. Copeland were also lent to the Committee by Earl Crawford.

The thanks of the Committee are particularly due to the Directors of the Eastern Extension Australasia and China Telegraph Company for the use of their wires, to Mr. Browning, manager of the Singapore office, for assistance rendered to Capt. Darwin at Singapore, and to the Batavian Government and Capt. Helb for assistance rendered at Banjoewangy in the determination of the Australian longitudes.

The Committee had the benefit of the services of Mr. Robert W. F. Harrison as Secretary up to 1882, April 30, and from that date of Mr. P. Edward Dove, who, since 1884, April 1, has acted as Honorary Secretary, without remuneration.

At the request of the Committee, Mr. E. J. Stone has undertaken the duties of Directing Astronomer in connexion with the arrangements for the observations of the Transit of Venus, and with the subsequent deduction of the results. Mr. Stone's report is herewith appended.

G. G. STOKES, Chairman.
J. C. ADAMS.
W. H. M. CHRISTIE.
J. R. HIND.
GEO. HENRY RICHARDS.
E. J. STONE.
P. EDWARD DOVE, Honorary Secretary.

REPORT of the DIRECTING ASTRONOMER on the reduction of the observations of the TRANSIT of VENUS 1882, December 6, with the results deduced therefrom.

CALCULATIONS.

The Right Ascensions, North Polar Distances, and Radii Vectores of the Sun and Venus have been interpolated from the Nautical Almanac.

The value of the solar parallax adopted in the calculations has been $\pi = 8''\cdot85$.

The angular semi-diameter of the Sun at the mean distance of the Earth has been assumed to be equal to 960″; and the semi-diameter of Venus at the mean distance of the Sun from the Earth to be equal to $8''\cdot472$; and with these data the residual errors have been formed.

δs is the relative correction in seconds of arc required by the semi-diameter of the Sun and Venus computed with these data, and $\delta\alpha$, $\delta\Delta$, are the corrections which the tabular Right Ascensions and the North Polar Distances require in seconds of time and arc respectively.

Col. Clarke's constants for the figure of the Earth have been adopted in the calculations.

The greater part of the arithmetical computations have been made by Mr. H. J. Carpenter, to whom my thanks are due for the accuracy with which the work has been done.

CONTACT OBSERVATIONS.

The observations of contact have been arranged to afford two independent determinations of the Sun's distance from a comparison between the contacts made at two classes of stations—

A. { Contact at ingress accelerated by parallax.
Contact at ingress retarded by parallax.

B. { Contact at egress accelerated by parallax.
Contact at egress retarded by parallax.

INGRESS OBSERVATIONS.

Of the observable contacts in a Transit of Venus those near the internal contacts at ingress were expected to yield the most satisfactory results. The times recorded at the external contacts are merely the times when the observer first saw the planet Venus projected on the Sun's disc. The recorded times, therefore, greatly depend upon the fact whether the observer's attention was or was not directed to the part of the Sun's limb at which the contact first took place. The times recorded are all late; and the estimations which some of the observers have given of the degree of lateness are not such that accurate calculations could be based upon them. It was not expected that any accurate value of the Sun's distance would be obtained from the discussion of the times recorded for the external contact at ingress. But these observations have been discussed chiefly with a view of testing the extent to which, considering the somewhat discordant material available from the observations of the external contact at ingress, we may trust to the assumption that the recorded times refer to a phase which takes place with the same angular separation of the centres at all the stations. The result is so far satisfactory that the value of the parallax thus deduced agrees well within its probable error with the most reliable results which can otherwise be obtained. The result thus obtained from the external contacts at ingress is—

$$\pi = 8''\cdot760 \pm 0''\cdot122.$$

With respect to the internal contacts there are at least four contacts of a more or less distinctive character which have been seen and described within a minute of time over which some connexion between the limbs, due to atmospheric disturbance or otherwise, appears under certain conditions and with an unclouded sky to extend: and any one of these phases may have been called "contact" by an observer.

These different kinds of contacts may be described as follows:—

(1.) Contacts between the Sun's limb and the limb of Venus as distinguished from contacts with the atmosphere of Venus. These contacts are sometimes spoken of as "geometrical contacts" and sometimes as "tangential contacts." The times at which such contacts took place are not usually recorded by the observers.

(2.) Contacts between the Sun's limb and the atmosphere of Venus, or "First flash of Sun's light through the atmosphere of Venus." Several observers have

recorded the times at which such contacts took place, and these contacts have sometimes been called by observers "geometrical contacts."

(3.) The last appearance of any well-marked and continuous disturbance of the illumination of the Sun's limb as distinguished from atmospheric tremor, or the time of some marked and striking change in the colour or character of the connexion between the atmosphere of Venus and the Sun's limbs.

(4.) The last appearance of a disturbance of the illumination of the Sun's limb from any cause whatever, or "disturbance from atmospheric tremor," "detached "portions of the atmosphere of Venus jumping backwards and forwards between "the limbs," "interference lines disturbance," or "full sunlight now between "Venus and the limb of the Sun."

These internal contacts appear to correspond to mean separations of the centres of Venus and the Sun of about—

(1) $942''\cdot 2$
(2) $941\cdot 4$
(3) $939\cdot 8$
(4) $938\cdot 6$.

The observers who have recorded times for the phases (1) and (4) are not sufficient in number to allow a value of the Solar Parallax to be obtained from their discussion with any pretensions to accuracy, but 11 observers have recorded times corresponding to phase (2), and these give a value of the mean Solar Parallax—

$$8''\cdot 874 + 0''\cdot 081,$$

a value which agrees within less than its probable error with the result obtained from a discussion of the principal phase.

Nearly all the observers who have recorded times for more than one phase of the internal contacts have described phase (3) as the most distinctive contact of the four; and in many cases it is described as the only distinctive contact. It will be assumed, therefore, that when only one time is recorded as the time of contact, the observer's recorded time refers to phase (3), unless the observations of contact were interfered with by cloud, and the observer expressly states that his observations are those of apparent or geometrical contact, in which case the observations have been treated as those of apparent contact, or phase (2), and included in the discussion of such contacts. There are only two such cases amongst the observations included in the present report, and in both these cases the recorded times are found to agree closely with the other recorded times for the apparent contact. When more than one time is recorded, the observer's selection of the distinctive phase which he wishes to have regarded as corresponding to "true contact," or as phase (3), has been accepted and used for the discussions.

A discussion of the 24 observations of internal contact at ingress which have been forwarded to the Committee gives a value—

$$8''\cdot 823 \pm 0''\cdot 023$$

for the value of the mean Solar Parallax. This corresponds to a mean distance of the Earth from the Sun of 92,654,000 ± 240,000 miles.

Egress.

The internal contact to which the attention was directed in the instructions to observers was described as follows:—

"The time of the first appearance of any well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun near the point of contact," to which was added the following explanation:—

"The expression '*well-marked* and *persistent* discontinuity in the illumination of the apparent limb of the Sun near the point of contact' is intended to guard observers against giving times for the contacts when there may be a *suspicion* only of some slight disturbance, haze, shadow, or interference phenomena. It is a point of primary importance that all the observers shall, as far as possible, observe the same kind of contact; and it is therefore desirable that the times recorded for contacts should refer to some marked discontinuity in the illumination of the Sun's limb, about which there cannot be a doubt, and which may be supposed to be recognizable by all the observers."

Many of the observers at egress have only recorded one time near the internal contact as the time of internal contact, but others have recorded two or three times, which are variously stated to correspond to—

(1) suspicion of haze or atmospheric tremor,
(2) haze or shadow,
(3) limbs of Sun obscured or geometrical contact.

The times corresponding to suspicion of haze or atmospheric tremor should not, in strict accordance with the instructions, have been recorded, and cannot, therefore, be combined with other times recorded for distinctive contact. It is possible, therefore, to consider the observations of contact when only one time is recorded as corresponding to either—

(2) haze or shadow,
(3) limbs obscured or geometrical contact.

The first assumption should be true if the instructions have been strictly carried out in all cases and the sky had at all stations been sufficiently clear for observation of the haze or shadow phenomena.

The second would assume that the observers who have only given a single time have not seen or have disregarded the haze or shadow contact, and have waited until the Sun's limb became obscured by shadow or haze as dark as the outer limb of the planet or the contact had become a geometrical contact.

The difference between the results thus obtained, although not inconsiderable, is well within their probable errors.

The first solution leads to a value—

$$\pi = 8''\cdot827 \pm 0''\cdot050;$$

the second would give the larger value—

$$\pi = 8''\cdot882 \pm 0''\cdot043.$$

The probable errors of these two results are so nearly equal that it has been thought desirable to give a third solution on the assumption that the mean of the times recorded for the different kind of contacts by some of the observers would on the average best agree with the kind of contact to which the single time records refer.

The value of the solar parallax thus obtained is—

$$\pi = 8''\cdot855 \pm 0''\cdot036.$$

The rather large probable errors of the first and second solutions of the equations, and the near equality of these probable errors would appear to point to the solution obtained by taking the mean times $8''\cdot855$ as the value which best represents the egress observations here collected. This value corresponds to a mean distance of the Earth from the Sun of 92,319,000 ± 370,000 miles.

The external contacts at egress give—

$$\pi = 8''\cdot953 \pm 0''\cdot048.$$

If we adopt the mean of the results for ingress and egress, the effects of any small error $\delta\alpha$ will be sensibly eliminated, and we should thus obtain from the internal contacts—

$$\pi = 8''\cdot839 \pm 0''\cdot021 - 0''\cdot0015\ \delta\alpha - 0''\cdot0063\ \delta\Delta,$$
$$\text{or } \pi = 8''\cdot825 \pm 0''\cdot028 - 0''\cdot0015\ \delta\alpha - 0''\cdot0063\ \delta\Delta,$$

according as we take the second solution or the first solution for the egress result. Those results agree so closely that the value—

$$8''\cdot832 \pm 0''\cdot024 - 0''\cdot0015\ \delta\alpha - 0''\cdot0063\ \delta\Delta$$

may be accepted as that which represents the internal contacts. This value corresponds to a mean distance of the Earth from the Sun of 92,560,000 ± 250,000 miles.

Details of Observations.

The following are the details of the observations given by the different observers. It has not been thought necessary to give the drawings in this Report.

MAURITIUS.

	h. m. s.	
Longitude of station - - -	3 50 12·0	E. of Greenwich.
Latitude ,, - - -	20° 5′ 39″	S.

Observations of the Contacts of the Sun and Venus.

Dr. C. Meldrum.

Observed with a 6-inch equatoreal by Cooke and Sons; power 150, with a first surface reflecting prism, and a neutral tint glass wedge. Times noted by chronometer Kullberg No. 3400.

Ingress.

The weather was unfavourable, but less so than had been expected. For several weeks previously there was scarcely a day on which the Transit could have been seen. In the forenoon of the 6th clouds began to gather, and as the time of the first external contact approached fully, seven-tenths of the sky were covered with cumuli, nimbi, and cirro-strati.

All preparations and arrangements having been made, I took up my post at the equatoreal four minutes before the expected time of the first contact; Mr. A. N. Figou, the Second Assistant, recorded the times.

Until 5h. 40m. 18s. L.M.T. by the chronometer, the Sun was obscured. He then shone out through cirro-strati.

5h. 41m. 24s. by chronometer. At this instant I thought something like smoke or a shadow had just impinged upon the Sun's limb near the point where the external contact was expected, and I called out "contact," but it was not until seven or eight seconds later that I was sure it was Venus. There was a good deal of boiling at the time.

From 5h. 41m. 24s. to 5h. 59m. 46s. clouds were passing off and on, and the Sun did not at any time shine in a completely clear sky. The planet when seen was intensely black, and apparently quite round, notwithstanding that there was always more or less boiling, and at times, much. Owing perhaps to the clouds and to my attention being mainly directed to the cusps and the dark space between them. I did not see, up to 5h. 59m. 46s., any part of the planet's limb illumined, but the place occupied by the portion of Venus outside the Sun appeared lighter than the rest of the background. Except when clouds were passing, the cusps were very distinct. At 5h. 59m. 46s. the Sun became completely obscured, and did not re-appear, and then only dimly, until 6h. 0m. 26s. From the glimpses obtained during the next ten seconds, it appeared that internal contact had not taken place.

The weather now cleared up a little, and at 6h. 0m. 42·5s. by chronometer, the limbs of the Sun and planet seemed to be connected by a haze or ligament, which blunted the cusps. On each side of what was about apparently to become the point of contact, the planet's limb was to some extent illumined. The haze and the aureola were diminishing. The planet did not appear to be inside the Sun's disc. It seemed that what was about to occur would be "pure geometrical contact."

6h. 1m. 3s. by chronometer. For an instant light seemed to flash in between the limbs and to connect the cusps, but instantly after a brown drop or button seemed to connect the limbs at the point of contact. This drop, however, lasted only about two seconds. In another second or two a fine thread of light separated the Sun and planet. The time given (6h. 1m. 3s.) is the instant of the last appearance of discontinuity in the illumination of the Sun's limb near the point of contact.

From 6h. 1m. 3s. to 6h. 1m. 27·5s. filmy clouds were passing, but, at the latter time, a distinct band of light separated the limbs.

Owing to an accident no photographs were taken. Preparations had been made for taking a number of pictures, but the first assistant (Mr. Bell) was blinded, and his mouth and tongue scalded by the contents of a bottle of ammonia, which he was opening, flying up into his face, between 1 and 2 o'clock on the 6th, and disabling him

for nine days. Extra assistants were at hand to take photographs, but it was found that the baths had been spoiled by the ammonia.

Collecting the times, we have—

	h.	m.	s.	
1. First seen - - - - -	5	41	24	by chronometer.
2. Connexion by haze or ligament -	6	0	42·5	,,
3. Last appearance of discontinuity, &c.	6	1	3	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	5	41	24	22	42	19·01	5	41	20·22	1	51	8·22
2.	6	0	42·5	23	1	40·75	6	0	38·78	2	10	26·78
3.	6	1	3	23	2	1·29	6	0	59·28	2	10	47·28

Whence the equations—

$$1.\ 5''.836 = -2{\cdot}160\,\delta\pi \quad -\delta R \quad -\delta\rho \quad +0{\cdot}522\,\delta\alpha \quad +0{\cdot}825\,\delta\Delta \quad -0{\cdot}053\,\delta t$$
$$2.\ 1{\cdot}988 = -2{\cdot}143\,\delta\pi \quad -\delta R \quad +\delta\rho \quad +0{\cdot}481\,\delta\alpha \quad +0{\cdot}854\,\delta\Delta \quad -0{\cdot}051\,\delta t$$
$$3.\ 3{\cdot}022 = -2{\cdot}142\,\delta\pi \quad -\delta R \quad +\delta\rho \quad +0{\cdot}480\,\delta\alpha \quad +0{\cdot}854\,\delta\Delta \quad -0{\cdot}051\,\delta t$$

MADAGASCAR.

	h.	m.	s.	
Longitude of station - -	2	54	24·01	E. of Greenwich.
Latitude ,, - -	23°	38′	57″·6	S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Rev. S. J. Perry.

Observed with a 6-inch Simms' equatoreal; power 150, negative eye-piece with solar prism and graduated wedge. Times noted by chronometer Carter 380.

INGRESS.

Sky cloudless; high south wind. The telescope had been tested for illuminating and defining power on previous days. It shows exceedingly well the faculæ and mottled appearance all over the solar surface on any ordinary clear day. The fifth star in the quadrilateral of the nebula in Orion was clearly seen, and the sixth glimpsed. The companion of Rigel was a very easy object to observe, and that of α Arietis was just visible. With first magnitude stars, a purple halo surrounds the star when in focus; when the focus is shortened the green centre and rings are surrounded by a purple halo, and when the focus is lengthened, the purple centre is enclosed within well-defined greenish rings; the power used in these observations was 150. The driving clock was very uncertain in its rate, so every preparation was made to replace it and its slow motion cord by an ordinary Hooke's joint slow motion rod, if required. A series of measures of the distance of a well-defined spot from the E. limb of the Sun was made during the afternoon to test the performance of the double image micrometer, which was found to work fairly. The time was taken by Mr. W. Carlisle. The part of the wedge used during the transit was determined several times by noting the extreme positions in which a good definition could be obtained of the faculæ and granulations on the Sun's surface and adopting the mean. This adopted mean was found to agree very closely with the position given by using the least amount of light which would enable two spider lines placed 1″ apart to be well divided.

The field of the wires of the telescope, power 150, embraced about 30° of the Sun's circumference, and, as I placed at the centre of the field, the point of the limb 35° S. of the Sun's E. point, instead of 35° E. of the Sun's S. point, I did not see Venus till

she was partially on the Sun. I picked her up as I swept round the limb towards the south. The wavy motion of the Sun's limb was very considerable, the undulations being of great length, so it would have been impossible to observe external contact with even the ordinary accuracy of such an observation.

The wind from the S. was very high and clouds of sand descended upon us during the transit, but our telescopes were fairly protected by reed erections put up by the natives, and there was consequently little vibration in the Simms' achromatic. When Venus was about half on the Sun, her atmosphere first became visible. The upper portion of the limb of Venus outside the Sun was clearly seen, the planetary atmosphere being of a dull pearly white, much less bright than moonlight. The faculæ and mottled appearance of the Sun in the vicinity of the planet were well marked, and these served to fix the focus accurately.

At 20h. 35m. 0s. by chronometer, the lower part of the planet's limb outside the Sun became visible (Fig. 2), and at 20h. 35m. 51·2s., the whole of Venus was seen (Fig. 3). The atmosphere of the planet never increased in brilliancy, and I was able to watch it until it came into apparent geometrical contact with the Sun's limb at 20h. 41m. 37·5s. by chronometer. I might easily have observed the apparent contact of the inner darker portion of the planet with the Sun's limb, as this darker portion preceded very considerably that of the atmosphere, but I kept my attention fixed on the planet as a whole including its atmosphere, and neglected entirely the apparent contact of the inner dark circle. (Fig. 4) gives the apparent geometrical contact of the planetary atmosphere with the Sun's limb. There was no apparent departure of the planet from the circular shape, no drawing out of the limb of Venus towards the Sun's limb, but, after the apparent geometrical contact of the atmosphere of Venus with the Sun's limb, a dark shade remained behind the advancing planet.

At 20h. 42m. 1·6s. by chronometer, this shade diminished slightly in intensity (Fig. 5 to Fig. 6), and at 20h. 42m. 48·8s., I first suspected a break in the shade behind the planet.

At 20h. 42m. 59·9s. by chronometer, the well-defined and permanent ligament certainly ceased to exist. This last and most important phase may be represented by the change from (Fig. 6 to Fig. 7). The dancing shadow in (Fig. 7) I neglected altogether as the union between the limbs was no longer established by it. When Venus was well within the Sun's limb, I touched the focussing screw, and I felt convinced at the moment that the planet might have been focussed more sharply; still the test of clearly seeing the mottled appearance all over the solar surface appeared to be satisfactory. A light around Venus was still visible on her following limb when she was entirely on the Sun, but this soon gave way to the slaty appearance of the rest of the planetary disc, and was probably not due to the atmosphere of Venus.

After Venus had been on the Sun for several minutes, I tried the double image micrometer for measuring diameters and distances of limbs, but the driving clock of the equatoreal worked so indifferently, owing possibly to the falling sand, which penetrated everywhere, that I soon came to the conclusion that no reliable measures could be taken, and therefore preferred comparing the chronometer at once. During the transit I was obliged to discard the driving clock and use an ordinary slow motion rod for the A.R. circle. Throughout the observations the sky was cloudless, but the high wind and sand interfered a little.

Collecting the times relating to the contacts, we have—

	h.	m.	s.	
1. Geometrical contact - -	20	41	37·5	by chronometer.
2. Break suspected - - -	20	42	48·8	,,
3. Well-defined and permanent ligament certainly ceased to exist - - -	20	42	59·9	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	41	37·5	22	5	22·48	5	4	20·60	2	9	56·59
2.	20	42	48·8	22	6	33·97	5	5	31·90	2	11	7·89
3.	20	42	59·9	22	6	45·10	5	5	43·00	2	11	18·99

Whence the equations—

$$
\begin{aligned}
&1.\ -0''.782 = -2.003\,\delta\pi - \delta R - \delta\rho + 0.482\,\delta\alpha + 0.853\,\delta\Delta - 0.051\,\delta t\\
&2.\ +2.837 = -2.003\,\delta\pi - \delta R + \delta\rho + 0.480\,\delta\alpha + 0.854\,\delta\Delta - 0.051\,\delta t\\
&3.\ +3.402 = -2.003\,\delta\pi - \delta R + \delta\rho + 0.479\,\delta\alpha + 0.855\,\delta\Delta - 0.051\,\delta t
\end{aligned}
$$

Observations of the Contacts of the Sun and Venus.

Rev. W. Sidgreaves.

Observed with a 6-inch equatoreal; power 150. Times noted by chronometer Roskell.

Ingress.

Geometric contact of illuminated atmosphere of Venus at 23h. 31m. 48·2s. by chronometer (1).

Last appearance of darkest shade between planet and Sun at 23h. 32m. 13·2s. by chronometer (2).

Last appearance of *any* shade between planet and Sun at 23h. 32m. 18s. by chronometer (3).

The *darkest shade* mentioned in phenomenon (2) was *not* dark. It was reduced to a faint shade caused by the continuance of the bright ring of atmosphere round the planet. This bright ring remained until the contact was clearly over. My telescope has been all along extremely sensitive to the wind or the slightest touch. Even a careless move of the slow motion rods has always made a star or the Sun dance in the field. The wind was high during the transit; but, by the kind assistance of Captain Aldrich (H.M.S. "Fawn"), a large screen had been erected to protect the instrument against the wind. This succeeded admirably until the critical moment. A gust of wind caught the instrument just at the time of (2) and (3), and made the tube oscillate to an amount which made it extremely difficult to watch the delicate shade of contrast between the bright ring round the planet and the sunlight. The definition was perfect. I could see the rice grains and faculæ extremely well.

Collecting the times, we have—

	h.	m.	s.	
1. Geometric contact of illuminated atmosphere of Venus - -	23	31	48·2	by chronometer.
2. Last appearance of darkest shade between planet and Sun - -	23	32	13·2	,,
3. Last appearance of *any* shade between planet and Sun -	23	32	18	,,

Comparison of Roskell with sidereal clock—

Date.	Time by Sidereal Clock.			Time by Roskell.			Correction of Roskell to Local Mean Time. + signifies *Slow*.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1882 December 6	21	25	16·0	22	51	0·0	+5	33	11·94
,, ,,	22	16	25·0	23	42	1·0	+5	33	11·88

We therefore get for times of contacts—

Ingress.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	23	31	48·2	22	6	2·07	5	5	0·09	2	10	36·08
2.	23	32	13·2	22	6	27·14	5	5	25·09	2	11	1·08
3.	23	12	18·0	22	6	31·95	5	5	29·89	2	11	5·88

Whence the equations—

$$
\begin{aligned}
&1.\ 1''.223 = -2.003\,\delta\pi - \delta R - \delta\rho + 0.481\,\delta\alpha + 0.854\,\delta\Delta - 0.051\,\delta t\\
&2.\ 2.493 = -2.003\,\delta\pi - \delta R + \delta\rho + 0.480\,\delta\alpha + 0.854\,\delta\Delta - 0.051\,\delta t\\
&3.\ 2.740 = -2.003\,\delta\pi - \delta R + \delta\rho + 0.480\,\delta\alpha + 0.854\,\delta\Delta - 0.051\,\delta t
\end{aligned}
$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Commander P. Aldrich, R.N.

Observed with a 4-inch equatoreal; power 175; there was no prism attached to the eye-piece, a neutral tint wedge was placed between it and the eye. The fittings for this together with a slow motion focussing screw having been made for me under the direction and on the plan of Mr. G. H. Weeks, the Chief Engineer of the "Fawn." Times noted by Lieut. E. C. H. Helby, R.N., by pocket chronometer Dent 19974.

INGRESS.

A northerly wind had been blowing for some days prior to the 6th, and clouds obscured the Sun at 4 p.m. for three or four days before the transit. The morning of the 6th was very overcast and cloudy, with a little E.S.E. wind, which freshened after 8 a.m., followed round with the Sun, and rapidly cleared the sky of cloud. In the afternoon the wind was fresh, force 4·5 from the S.S.W. and S.W., the atmosphere very clear, and the Sun very bright.

The telescope was somewhat shaky; it was equatoreally mounted on a wooden tripod stand, but I had had a large tent of oars and canvas pitched over it, without which I do not think any observation could have been satisfactorily made.

The heat of the Sun was so great that during 20 minutes before the transit a small speck or two of the colouring matter on the wedge was apparently removed by it. This, however, only necessitated my moving the wedge about one-eighth of an inch nearer to the darker end, and did not ultimately interfere with what I had decided on as the most convenient depth of shade. There being no prism attached to the eye-piece, the Sun had to be faced, but the glare was to a great extent diminished by a canvas screen carried across the tent under the telescope.

The definition was fair, though not comparable with those as viewed in the 6-inch telescopes; the rice grains were beautifully distinct in the latter, but could not be well distinguished in the 4-inch.

The watch having been compared, Helby and I were in readiness at 4.30 p.m. M.T.P., and at 6h. 21m. 0s. by watch I saw a slight indentation or notch in the Sun's limb in the middle of the field, which I concluded was Venus. I gave the signal, and after watching for a few seconds to see that I was not mistaken, I called Helby to come and look at it. I hesitate to estimate how long this was after external contact, but probably over a minute, and possibly more. From this time I did not observe anything worth recording till Venus was nearly, if not quite, half way on the Sun's disc. At this time, 6h. 33m. 1·2s., a faint rim of light was seen to extend round the apparent upper half of Venus off the Sun, and within a very short time, at 6h. 33m. 51·2s., the ring was complete and the whole extent of Venus visible.

After this I observed nothing worth recording until 6h. 38m. 5s., when a black drop was apparently forming, and the edge of Venus about the Sun's limb became rather ill-defined.

The time here given may be considerably in error, but it was that at which I could first make certain of a wall-like appearance between the cusps.

At 6h. 39m. 42·4s. by chronometer, I considered apparent contact was made. This alludes to an instant when the edge of the luminous ring round Venus was estimated to be in contact with the Sun's limb. This phase was rather interfered with by a dark but very narrow band, which seemed to draw the limb of Venus towards the Sun's limb, with small perpendicular edges. And yet this did not assume what I had been led to believe was the appearance of the black drop. At this instant, however, there was no appearance of sunlight between Venus and the Sun's limb, and the "well "marked and persistent discontinuity in the illumination of the apparent limb of the "Sun" still continued.

At 6h. 40m. 14s. by chronometer, there was undoubted light between the apparent limb of the Sun and Venus, and the "well marked and persistent discontinuity" had ceased. I am inclined to think that I may have been perhaps a few seconds late in estimating, or rather, observing this, but I was hardly prepared for such a sudden termination of the observations. At this time, however, there was no doubt whatever about the internal contact being over.

After this there was a faint flickering narrow band, which extended from Venus to the Sun's limb, and had I not been particularly cautioned not to pay any attention to anything, after the sunlight had been seen, I think I should have thought this was the ligament; as it was, beyond watching it, I paid no attention to it, and Mr. Helby had

a look at it. This continued some little time after Venus was well clear of the Sun's limb, and no time was taken.

When Venus had got some half a diameter on the Sun I observed a faint luminous haze over the eastern side of the planet, first in the upper portion and then in the lower, till at length it became like a dull coloured moon or crescent on the part of the planet nearest to the Sun's limb.

A sheet of small sketches is forwarded with this, which may assist in showing what I actually saw.

Collecting the times relating to the contacts, we have—

	h.	m.	s.	
1. First seen - - - -	6	21	0	by chronometer.
2. Estimated apparent contact - -	6	39	42·4	,,
3. Light between Venus and Sun -	6	40	14	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	6	21	0	21	47	19·67	4	46	20·75	1	51	56·74
2.	6	39	42·4	22	6	5·10	5	5	3·11	2	10	39·10
3.	6	40	14	22	6	36·79	5	5	34·71	2	11	10·70

Whence the equations—

$$1.\ 6''{\cdot}989 = -1{\cdot}998\,\delta\pi - \delta R - \delta\rho + 0{\cdot}521\,\delta\alpha + 0{\cdot}825\,\delta\Delta - 0{\cdot}053\,\delta t$$
$$2.\ 1{\cdot}371 = -2{\cdot}003\,\delta\pi - \delta R + \delta\rho + 0{\cdot}481\,\delta\alpha + 0{\cdot}854\,\delta\Delta - 0{\cdot}051\,\delta t$$
$$3.\ 2{\cdot}977 = -2{\cdot}003\,\delta\pi - \delta R + \delta\rho + 0{\cdot}479\,\delta\alpha + 0{\cdot}855\,\delta\Delta - 0{\cdot}051\,\delta t$$

DURBAN.

The observations were taken at the Natal Observatory by Mr. E. Neison.

The longitude of the station determined telegraphically from the Royal Observatory, Cape of Good Hope, and supplied by Dr. Gill is :—

h. m. s.
2 4 1·18 E. of Greenwich.

The latitude is—

$29^\circ\ 50'\ 47''{\cdot}4$ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. E. Neison.

Observed with the 8-inch equatoreal of the Natal Observatory, reduced by means of a cardboard stop to 6-inches; power 160 on a Merz polarising eye-piece. Definition very unsteady. Times noted by chronometer Poole 1407.

INGRESS.

External contact lost owing to unsteadiness.

Internal contact observed at 4h. 17m. 59s. by chronometer.

As Venus approached internal contact a thick dark ligament was seen, gradually narrowing till about 10″ wide, then it commenced to lighten, flickered a little, grew greyish in hue and suddenly broke up, a narrow line of light darting across the grey shade, and the whole shading vanished in less than five seconds. The time was the instant when the shading broke up. A second or so more, and sunlight was distinctly visible between Venus and the limb. This was at 4h. 18m. 6s. by chronometer. At this time contact was past. The ring of atmospheric light was yellowish in hue and was distinctly seen from the time that Venus was half on the Sun, and it did not disappear till a minute after it was quite on the Sun. Traces of it could be distinctly seen for some time after.

The time was read out aloud and recorded by Mr. P. Sandford of the Durban High School.

We therefore get for time of contact—

INGRESS.

Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
4	17	59	21	16	36·13	4	15	33·99	2	11	32·81

Whence the equation—

$$3''\cdot225 = -1\cdot903\,\delta\pi - \delta R + \delta\rho + 0\cdot481\,\delta\alpha + 0\cdot854\,\delta\Delta - 0\cdot051\,\delta t$$

CAPE OF GOOD HOPE.—ABERDEEN ROAD.

The country round about the station is almost a desert, "The Karroo," and the definition of the Sun in the middle of the day or afternoon was never good. By 7 a.m. everything at a short distance could be seen quivering to an extent never before witnessed.

The longitude of the station determined telegraphically from the Royal Observatory, Cape of Good Hope, and supplied by Dr. Gill, is—

h. m. s.
1 37 15·62 E. of Greenwich.

The latitude, also supplied by Dr. Gill, is—

$32^\circ\ 45'\ 56''\cdot5$ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. W. H. Finlay.

Observed with a 6-inch equatoreal, positive eye-piece, power about 180. The brightness of the field was carefully regulated in accordance with the instructions of the Committee. Times noted by chronometer, Molyneux, 2184.

INGRESS.

The Sun's limb was boiling excessively up to about a minute before the time of external contact. It then became much steadier, and contact was noted at 3h. 28m. 55s. by chronometer. The notch was very small when first seen, and was exactly at the point where I was looking.

When Venus was half way on to the Sun's disc that part of the planet still outside was visible as a darker body on a lighter background, with a very faint rim of light at the outer preceding edge. This light got brighter and gradually crept round the edge till at 3h. 42m. it extended completely round.

At 3h. 47m. 45s. the *dark* body of Venus and the Sun's limb produced would have been tangential, but the ring of light still extended outside.

The cusps of the Sun came gradually closer, till at 3h. 48m. 16s. by chronometer, the dark body of Venus was quite inside the Sun, while the bright ring just extended to the Sun's limb, and a light brown shade was visible all across the space between. This shading was always *very* light, and did not change colour, so far as I could see. It gradually got fainter and narrower in the direction perpendicular to the line of centres. The Sun's limb was now boiling, but at 3h. 48m. 57s. by chronometer, there seemed to come a roll of sunlight, which swept the haze right away, and, after this, though some slight disturbances, two or three little streaks of haze jumping from one limb to the other were seen for a few seconds; there was no more continuous connexion.

When Venus was well on the Sun there seemed to be a portion of the disc round the outside and of a breadth equal to about one-eighth of the diameter, when the planet was not so dark as over the rest, but this was a totally different thing in size and appearance to the bright rim seen before.

Collecting the times relating to the contacts, we have—

	h.	m.	s.	
1. First contact - - - -	3	28	55	by chronometer.
2. Tangential contact - - -	3	47	45	,,
3. Last permanent connexion - -	3	48	57	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sideral Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	3	28	55	20	29	53·89	3	28	55·02	1	51	39·40
2.	3	47	45	20	48	47·05	3	47	45·09	2	10	29·47
3.	3	48	57	20	49	59·25	3	48	57·09	2	11	41·47

Whence the equations—

$$1.\quad 4''\!\cdot\!086 = -1\cdot774\,\delta\pi - \delta R - \delta\rho + 0\cdot525\,\delta\alpha + 0\cdot822\,\delta\Delta - 0\cdot054\,\delta t$$
$$2.\quad -0\cdot689 = -1\cdot824\,\delta\pi - \delta R + \delta\rho + 0\cdot484\,\delta\alpha + 0\cdot851\,\delta\Delta - 0\cdot051\,\delta t$$
$$3.\quad 2\cdot999 = -1\cdot827\,\delta\pi - \delta R + \delta\rho + 0\cdot482\,\delta\alpha + 0\cdot853\,\delta\Delta - 0\cdot051\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. R. T. Pett.

Observed with a 6-inch equatoreal, positive eye-piece; power about 180. Times noted by chronometer Molyneux 2275.

INGRESS.

First external contact at 20h. 25m. 0s. by chronometer.

Sun's limb boiling terribly for some little time before contact, but quieted down about a minute before times noted. Venus appeared just where I was looking.

First internal contact at 20h. 45m. 12s. by chronometer. The cusps seemed to unite suddenly. Bad definition at this time. No black drop or ligament seen.

At 20h. 45m. 30s. the band of light was of sensible width.

I do not think that I was more than two or three seconds out in either observation.

Collecting the times relating to the contacts we have:—

	h.	m.	s.	
1. First external contact - -	20	25	0	by chronometer.
2. First internal contact - -	20	45	12	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	25	0	20	29	50·95	3	28	52·09	1	51	36·21
2.	20	45	12	20	50	3·29	3	49	1·12	2	11	45·24

Whence the equations—

$$1.\quad 3''\!\cdot\!929 = -1\cdot774\,\delta\pi - \delta R - \delta\rho + 0\cdot525\,\delta\alpha + 0\cdot822\,\delta\Delta - 0\cdot054\,\delta t$$
$$2.\quad 3\cdot201 = -1\cdot827\,\delta\pi - \delta R + \delta\rho + 0\cdot481\,\delta\alpha + 0\cdot853\,\delta\Delta - 0\cdot051\,\delta t$$

CAPE OF GOOD HOPE.—MONTAGU ROAD.

		h.	m.	s.
Longitude of station	- -	1	20	8·64 E. of Greenwich.
Latitude ,,	- -	33°	20′	23″ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. A. Marth.

Observed with a 6-inch Grubb equatoreal, a positive Steinheil eye-piece ; power 180. Times noted by chronometer Birchall No. 308.

INGRESS.

After a clear night which had allowed the occultation of Spica to be well observed, the morning of December 6 was cloudless and calm. Some strong gusts of wind, about 9 o'clock, however, indicated that the breeze which at Montagu Road springs up pretty regularly every forenoon, had come earlier and in greater strength than usual, and it soon became apparent that the day might be one of dust storms, of which we had already had sufficient unpleasant experiences during the last weeks, without yet having encountered any of those heavier ones of the occurrence of which we had been told. The day before a large tarpaulin, kindly lent by the railway officials, had been erected on poles on the south side of the hut containing the Grubb telescope in order to screen it from the dust and wind which of late had blown chiefly from the south-east. But on the day of the transit, the gusts of wind came from several directions, chiefly from the northern quarter, and fresh precautions had to be taken to shelter the instrument and to guard it from being too much shaken on its weak stand. The tarpaulin which serves as a covering of the hut was kept tied down on the eastern and northern side, and only the south-western portion was lifted up and so fastened to poles as to allow a free view of the Sun at the time of the transit. In doing this, sufficient allowance had not been made for the examinations preceding the ingress, but, by the exertions of Corporal Thornton, the alterations were effected in time, and his makeshift screening rendered observations with the Grubb telescope possible. The telescope is too heavy for its mounting, and consequently unsteady, even in the absence of wind. On the day of the transit, though screened from the force of the wind, it was very unsteady. To be prepared for the observation of the external contact, I had divided the circumference of the draw tube into 10 parts, so that each represented 36°, and it would be feasible to find the point of the Sun's limb, near which contact was to take place (in position-angle 145°) by first placing a web in the eye-piece in the direction of a parallel, and then shifting the draw tube 36° in the required direction, so that the web should become a tangent to the Sun's limb near the point in question. In consequence of the unsteadiness of the telescope, and of the excessive trembling of the sun-spot, by means of which I attempted to find the parallel, I had to be content with a rough determination, sufficient however, for the intended purpose (while I was thus engaged the air outside was so thick with the flying dust that Corporal Thornton afterwards stated that he had scarcely been able to recognize the outlines of the other huts at a distance of only nine steps).

At 3h. 11m. 58s. by chronometer, I remarked the first indentation of the Sun's limb made by the planet, but on account of the trembling I could not estimate by the rate of its increase how much too late I may have seen it.

At 3h. 17m. 10s. by chronometer, I saw the illuminated atmosphere of Venus outside the Sun along an arc of perhaps 50° of the planet's periphery. The centre of the arc was distant from the point opposite to the Sun perhaps 40° towards the south (or in position-angle 184°, if the position-angle of Venus at the centre of the Sun was 144°).

At 3h. 22m. the illuminated arc extends now nearly to the point opposite to the Sun.

At 3h. 23m. 10s., chronometer time, the whole rim of Venus outside the Sun appears illuminated. The image is becoming extremely disturbed. Violent commotions of image with occasional moments of better definition. In consequence, when looking for the geometrical contact, I could not satisfy myself what to consider as the Sun's circular outline.

At 3h. 31m. 6s. I became doubtful whether the refracted light in the atmosphere of Venus did not apparently broaden or extend outwards by some faint light.

At 3h. 31m. 38s. by chronometer, "last disturbance due to Venus" (expression jotted down to be understood as the "last appearance of persistent discontinuity in the illumination of the apparent limb of the Sun").

As soon as I had assured myself that my counting of the chronometer beats had been correct I tried to form an estimate of the degree of uncertainty of the time set down. The phenomenon actually observed had been simpler than the doubt of half a minute before had led me to anticipate. The direct sunlight had crept from both sides along the dull refracted light on the rim of Venus; up to the beat noted there had been "persistent discontinuity of the light of the Sun's limb," and immediately after the tiny thread of light between the cusps was established and was not further disturbed by the planet. If it had not been for a comparative lull in the trembling at the critical time, I should probably have been in great uncertainty. As it was, I felt no uncertainty that the phenomenon observed had occurred at the beat 38, and that, so far as I could judge, it was the phenomenon for which I had been watching. Shortly before the state of the images had threatened to render a trustworthy observation almost hopeless; it gave me therefore the greater satisfaction to be able to write down, "In spite of the trembling limbs I consider the observation fairly good," and I could not have noted the time of last disturbance four seconds earlier or later, or even two seconds.

During the ingress Venus had the appearance not of a disc, but of a globe, say, of pitch in continual ebullition. The outline of the planet was, on the whole, less disturbed than the Sun's limb. I could not discern the granulations of the Sun's surface with distinctness on account of the trembling. Later on, they became occasionally visible, and Venus appeared as a deep blue or purple disc with a black centre, the blackness of which extended on one side nearly to the rim, while on the opposite side the breadth of the purple was about one-half of the radius of the disc. The planet appeared surrounded or partly surrounded by a ring or halo of yellowish light, which, where it appeared broadest, faded away at a distance of perhaps a third of the radius from the rim. The broadest part of the yellow was near the broadest part of the purple.

Collecting the times relating to the contacts, we have—

	h.	m.	s.	
1. First seen - - - - -	3	11	58	by chronometer.
2. Refracted light in the atmosphere of Venus extends outwards by some faint light - - - -	3	31	6	,,
3. Last appearance of persistent discontinuity, &c. - - - -	3	31	38	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	3	11	58	20	13	26·49	3	12	27·50	1	52	18·86
2.	3	31	6	20	32	37·63	3	31	35·50	2	11	26·86
3.	3	31	38	20	33	9·72	3	32	7·50	2	11	58·86

Whence the equations—

$$1.\ 5''\!\cdot\!404 = -1\cdot683\,\delta\pi - \delta R - \delta\rho + 0\cdot524\,\delta\alpha + 0\cdot823\,\delta\Delta - 0\cdot054\,\delta t$$
$$2.\ 1\cdot519 = -1\cdot743\,\delta\pi - \delta R + \delta\rho + 0\cdot483\,\delta\alpha + 0\cdot852\,\delta\Delta - 0\cdot051\,\delta t$$
$$3.\ 3\cdot159 = -1\cdot745\,\delta\pi - \delta R + \delta\rho + 0\cdot481\,\delta\alpha + 0\cdot853\,\delta\Delta - 0\cdot051\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. C. M. Stevens.

Observed with a $4\frac{1}{2}$-inch equatoreal by Dallmeyer; a Herschelian prism and a neutral tint wedge were used. A negative eye-piece, power 145, was employed in noting first external contact; for internal contact a power of 185 was used. Times taken by chronometer Arnold 227.

Ingress.

The early morning was quite clear and calm, but at 21h. the first gust of wind came from the north-west, raising a large amount of dust. The direction was rather unusual, as the daily wind blows from an azimuth point directly opposite, viz., south-east. The wind continued in the same direction with increasing force, till at midday it was blowing with a horizontal velocity of from 12 to 15 miles per hour, carrying with it dense clouds of very fine dust raised from the surface of the ground surrounding the Observatory, a space of 8 or 10 acres in extent, and almost entirely bare of shrubs and grass. At times the buildings in the camp a short distance off were almost completely obscured. I have noted that the winds here, whether they blow from the N.W. or S.E., usually rise about 9 a.m., and continue through midday and afternoon until evening, when they subside and leave the nights almost invariably calm.

I employed the same means as Mr. Marth for getting external contact.

As the time approached of first (external) contact the roof of the hut was opened, one section only being removed, and the instrument brought to bear upon the Sun, my seat being placed in a very convenient position for observing. A calico screen was nailed up to protect my head from the rays of the Sun, the temperature at the time being considerably over 100° F. in the shade. A canvas screen was also nailed up to protect the chronometer, as well as the back of my assistant, Mr. J. E. Willis, of the Telegraph Department, whose services I had enlisted in order that the chronometer times might be properly checked. The screen was not quite effectual, as the chronometer was for a time exposed to the rays of the Sun. This could not then be remedied, as I could not permit the chronometer to be moved, as it had been specially placed for my convenience, and there was no time to arrange any other protection.

Commencement of Transit.

(All the times given are by Arnold 227).

19h. 42m. 6s. First encroachment of planet detected. Must have been on half a minute or more. As the device failed for determining the position angle of first contact I guided the telescope by hand along the edge of the Sun, and carefully watched for the first notching into the Sun's limb.

19h. 48m. 20s. Slight rounding off of planet's limbs at points of junction with the Sun.

19h. 50m. 10s. First noted difference of colour in disc of planet and irregularity of distribution, "chiefly on north side."

19h. 52m. 56s. When I first saw the whole disc, including the part off the Sun, and a silvery light along the southern edge, starting from the Sun's limb. Slight rounding of the cusps.

19h. 54m. 50s. Silvery light now all round the following limb of the planet. Colour of part of Venus off the Sun, dark olivaceous green shot with a tinge of yellow.

19h. 57m. 50s. Light sharp all round following limb of planet.

Shortly after this time I gave the signal to Willis to attend carefully.

20h. 0m. 0s. Geometric contact. At this time the limbs of Venus and the Sun were in mathematical contact. Wind lulling; vibration slight in the instrument. Sun's limb tremulous; definition variable. This observation is nevertheless good.

20h. 0m. 40s. First glimmer (or thin streak) of light between Venus and Sun's limb. No black drop seen. Appearance of light instantaneous or nearly so, what I suppose Johnson saw at Waimea. I take this to be the time of true contact in accordance with the instructions, or say between 0m. 40s. and 0m. 45s.

20h. 0m. 45s. Glimmer of light between limbs decided. I consider the time of *true contact* to have been at the time when I first noted the intervention of the light between the limbs of the Sun and Venus at 20h. 0m. 40s., *i.e.*, the time of last appearance of any well-marked discontinuity in the illumination, &c. Persistent discontinuity was well marked at 20h. 0m. 45s.

Shortly before the time given as true contact, or at about 20h. 0m. 30s., I noticed an exceedingly narrow black line or filament tangential to the limb of Venus, and connecting the planet with the Sun. To this I would have given the name apparent contact, but that I did not note the exact time. This was the only appearance of a ligament that I saw. It was very much longer than it was broad, being only a very small fraction of a second of arc by estimate, and very soon gave place to the first glimmer of light at the time recorded.

I saw no Chinaman's cap, as in the artificial transit. 20h. 1m. 12s. "Fully on disc," implying the time when the thread of light became so firmly established—the "well-marked and persistent discontinuity" so far past—that I did not deem it necessary to record any further times.

This completed my observations at the critical period of internal contact. I am satisfied with them, not having been distressed by nervous excitement, fatigue of body, or special fatigue of the eye consequent on long gazing. The use of the medium portion of the wedge prevented the slightest distress to my eye during the whole period of observation.

The times noted by Mr. Willis and myself agreed, so that no error of a minute or half-minute can have crept in.

After first contact I used a power of 185, as I deemed the conditions sufficient to warrant the higher power. The definition much improved subsequent to the internal contact, after the planet had been about an hour on the Sun. I could see the "rice-grain" granulations then, but had not noticed them before, as I had been too absorbed in observing other phenomena. The driving clock of the instrument worked satisfactorily.

Fig. VI. (coloured drawings) represents the excentric position of the dark oval spot on the planet's disc, together with the irregular width of the purplish light extending inwards from edges of discs. These differences in colour marking became more deeply marked by using the extreme dark end of the wedge. This drawing was made about 20½h. by Arnold.

Fig. VII., drawn from Fig. VI. on original sheet, represents the time when I first noticed a yellowish coloured illumination all round the disc of Venus. This coincided in direct relationship of breadth and intensity with the purple colour on the disc itself. This encircling colour was a light canary yellow or "*écru*" at the limits of the band, while the portion immediately adjacent to the planet's limb at the broadest part was of a dusky tinge, between smoky yellow and orange. The direct connexion as to breadth, position, and intensity of this halo of light with the colour on the planet's disc was very remarkable.

As a physical question it may have some interest, as possibly bearing on the subject of the phenomena attending the internal contacts at ingress and egress. Judging from the position this halo would occupy in Drawing III., IV., V. (inferred from the purple band), I beg to venture the opinion that the position angle on the planet of internal contact at ingress was at a point remote from the zone of greatest density. And this leads me to remark that in reviewing the circumstances and phenomena attending the transit, particularly at the critical period of internal contact, I was surprised at their comparative simplicity. The absence of complex features such as would tend to create difficulty or uncertainty in noting the times being appreciable. Had the position angle of internal contact been at the densest portion of the halo observed, I venture to think that the phenomena would have been much more complicated.

During the earlier stages of ingress I noticed the rounding of the cusps, but at the time of internal contact it was not noticed at all. I do not say it was absent, only I did not look for or observe it. The text of the instructions as to noting "the last appearance, &c." was constantly present to my mind, and this undoubted bias may have prevented my noticing one of the phenomena contributing thereto. If the rounding were present, it certainly was not so remarkable as to obtrude itself on my notice.

If the broadest portions of the halo may be considered as indicating approximately the position of line of the equator of Venus, the position angle was remote therefrom.

The planet appeared circular to my mind, and no trace of a satellite could be seen, although carefully looked for.

At a later stage I used a power of 300, which revealed nothing that had not been noted before.

The temperature was 102° F. in transit hut at 21h. 8m. (sidereal), and 104° F. at 21h. 18m. (sidereal) in Grubb hut. I did not register the temperature in the Dallmeyer hut. Barometer reading 27·14 ins. corrected.

In conclusion I would beg to record the services rendered by Mr. J. E. Willis of the Telegraph Department here, whose training and assistance in the longitude signal work, added to his natural intelligence, warranted me in enlisting his services as a check on my chronometer times. I had on the previous day rehearsed the circumstances and conditions of the transit with him in the Dallmeyer hut. He performed his work quite satisfactorily.

Collecting the times relating to contacts, we have—

	h.	m.	s.	
1. First seen - - - -	19	42	6	by chronometer.
2. Geometric (tangential) contact; limbs in contact - -	20	0	0	,,
3. First glimmer of light between Venus and the Sun - -	20	0	40	,,
4. "Fully on disc" discontinuity so far past that it was unnecessary to record any further times -	21	1	12	,,

We therefore get for times of contacts:—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	19	42	6	20	14	1·16	3	13	2·08	1	52	53·44
2.	20	0	0	20	31	56·86	3	30	54·84	2	10	46·20
3.	20	0	40	20	32	36·93	3	31	34·80	2	11	26·16
4.	20	1	12	20	33	8·96	3	32	6·75	2	11	58·11

Whence the equations—

$$
\begin{array}{ll}
1. & 7''{\cdot}263 = -1{\cdot}683\,\delta\pi - \delta R - \delta\rho + 0{\cdot}523\,\delta\alpha + 0{\cdot}824\,\delta\Delta - 0{\cdot}054\,\delta t \\
2. & -0{\cdot}560 = -1{\cdot}741\,\delta\pi - \delta R + \delta\rho + 0{\cdot}484\,\delta\alpha + 0{\cdot}851\,\delta\Delta - 0{\cdot}051\,\delta t \\
3. & 1{\cdot}477 = -1{\cdot}743\,\delta\pi - \delta R + \delta\rho + 0{\cdot}483\,\delta\alpha + 0{\cdot}852\,\delta\Delta - 0{\cdot}051\,\delta t \\
[4. & 3{\cdot}118 = -1{\cdot}741\,\delta\pi - dR + \delta\rho + 0{\cdot}483\,\delta\alpha + 0{\cdot}852\,\delta\Delta - 0{\cdot}051\,\delta t]
\end{array}
$$

Noted by observer "All over" before the time to which the residual 4 corresponds.

CAPE OF GOOD HOPE.—ROYAL OBSERVATORY.

	h.	m.	s.	
Longitude - - - -	1	13	54·74	E. of Greenwich.
Latitude - - - -	33°	56′	3″·5	S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Dr. D. Gill.

Observed with a 6-inch Grubb equatoreal; a first surface reflecting prism; power 110. Times noted by Mr. Gamble, hydraulic engineer of the Colony, who kindly volunteered his services, with sidereal chronometer Dent 1581, and by Mr. Fry, Meteorological Secretary, with mean time chronometer Molyneux 3299.

The object-glass of the instrument is of excellent quality, as proved by its sharp and easy separation of the double stars Σ 2055 (1″·7) and Σ 2799 (1″·4) and by the sharp manner in which details on the lunar and planetary surfaces are shown.

Unfortunately only four eye-pieces, adapted to the two first surface prisms and dark wedges were supplied by the Committee. These eye-pieces magnified approximately 110, 180, 300 and 400 diameters. It was impossible, therefore, with so limited a supply to follow the instructions of the Committee and employ a power of at least 150 diameters, as the eye-pieces were for the Merz equatoreal as well as the Grubb, unless the air was sufficiently steady to permit the use of a power as high as 300 diameters. Nor was any positive achromatic eye-piece provided, as was done for the stations at Aberdeen Road and Montagu Road. Dr. Gill accordingly gave Mr. Maclear the 180 power, and reserved to himself the choice of powers 110 and 300.

Unfortunately the atmospheric conditions would not permit the use of a power higher than 180, and, even with this power, the images were "waving" and unsatisfactory. Up till the time that the disc of Venus was bisected by the Sun's limb,

attempts were made from time to time to focus with the power of 300, but in vain, only a violently agitated outline could be distinguished, and it was evident that any attempt to observe with such a power, under the circumstances, could only end in complete failure, Dr. Gill therefore adopted power 110, and focussed as sharply as possible on the Sun's limb. In moments of quiet definition some faculæ could be made out, but the rice grains, or mottled appearance of the Sun's disc easily seen with this power (110) on November 15, could not be distinguished.

INGRESS.

I made no attempt to estimate accurately the time of external contact. There was no provision for measuring position angles, and therefore no means of setting on the exact point where contact should be expected.

20h. 9m. 47s. by Dent 1581, or 1h. 9m. 5s. by Molyneux, I first saw Venus on the Sun's limb, but obviously some seconds after true contact.

Signal 2. Ligament changing colour.

,, 3. Disappearance of any continuous ligament or connexion.

The definition very unsteady. Waves of atmospheric undulation passing round limb. Obliged to use lowest power (110). Shade wedge was set to mean point, that is the middle point between shade decidedly too dark and decidedly too light for distinct vision.

In the evening after all observations were over, I was very tired, and entered only the following additional memoranda in my note book.

Signal 1 was given when I thought I saw a change of colour. I saw immediately it was an effect of the atmosphere. *See* Fig. 1.

Signals 2 and 3 represent as nearly as I could judge the instants of the two phases described by Mr. Stone, *i.e.*,

b. brighter than planet.

b. ceases to be continuously darker than the cusps *a* and *c*.

These remarks refer to Mr. Stone's last definition of the phases to be observed as afterwards quoted in this Report, p. 12. Mr. Stone, however, denotes the cusps by *a* and *b*, and the point of contact by *c*.

In the first hurried note I was anxious to make it quite clear that my first signal was not intended to record any phase of contact. Therefore I marked it as a "warning signal" to prevent possible after mistake, and I made the after note to remind me of the exact circumstances under which that warning was given.

These circumstances, as nearly as I can represent them, are shown in Fig. 1. The images were unsteady, the planet seemed to be approaching geometrical contact, and I was carefully watching for such phenomena as might present themselves. The images became more tranquil and I saw a long narrow curved line of light joining the cusps (Fig. 1). I called "stop," but immediately after doing so I saw that this arc of light which joined the cusps was not only different in colour from the cusps, but was also of uniform breadth, and obviously due to the atmosphere of Venus. This was confirmed by the fact that the cusps continued to approach each other, shortening the arc of light, but not changing its apparent breadth.

Before the cusps met I lost sight of this ring of light, whether in reality or because all my attention was concentrated on the point of contact, I cannot say; and there appeared between the points of the approaching cusps a dark junction or ligament which gave to the cusps a slightly blunted form.

20h. 10m. 30s. by Dent.—I cannot be certain whether this is an optical illusion or not, but I fancy I can see the portion of Venus outside the Sun.

20h. 17m. 30s. by Dent.—My impression that I can see half Venus outside the Sun is stronger, but the atmosphere of Venus is not visible.

20h. 20m. 0s. by Dent.—I am now tolerably certain that I can see a portion of Venus outside the Sun's disc.

20h. 25m. 0s. by Dent.—I suspect appearance of atmosphere of Venus.

20h. 25m. 30s. by Dent.—I am certain I see the whole of Venus with "slight halo."

In connexion with the above notes I would add the following remarks.

On further reflection I am inclined to question my conclusion that the dark body of Venus was really seen outside the Sun. If we consider the process by which the mind would convince itself that the eye dimly perceived a dark object on a very slightly less dark background, the form and position of the suspected object being known, we find that the eye would seek for a contrast of light round the approximately known border of the dark object, and, if such contrast were found, the mind would be impressed

with the idea that the dark body could really be distinguished. Now, under the unfavourable circumstances of definition, the ring of light, produced by the refraction of sunlight through the atmosphere of Venus, or by illumination of particles in the atmosphere, was not sufficiently well-defined to be at first objectively distinguished, but was still sufficiently visible to indicate a difference of shade sufficient to produce the subjective impressions above described at 20h. 10m. 30s., 20h. 17m. 30s., and 20h. 25m. 0s.

As the critical phase of internal contact approached, Mr. Gamble and Mr. Fry were cautioned to look out for the simple signal "stop," and to note the nearest *second* corresponding to each one of such signals, without any remark.

Three such signals were given by me, and recorded as follows—

	Mr. Gamble. Chronometer Dent 1581.			Mr. Fry. Chronometer Molyneux.		
	h.	m.	s.	h.	m.	s.
2.	20	29	54	1	28	0
3.	20	29	29	1	28	34
4.	20	29	48	1	28	54

Immediately after giving these signals, I entered the times recorded in my note book, with the following brief notes.

My first "stop" signal was a warning that "contact approaching."

At signal 3, this ligament changed from a dark to a grey or light brown colour, or, from the phase shown in Fig. 2 to that in Fig. 3, much as in the model at time of true contact. It should be understood that the ligament did not suddenly become as long as shown in Fig. 3; that figure is intended to represent its length immediately preceding its disappearance at signal 4.

In model practice, when the air is steady, this latter ligament disappears almost instantly, but in the present case it formed "a well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun near the point of contact" till it disappeared at signal 4, leaving only a pale yellow shade behind which could not be so defined. In fact I cannot better define the two phenomena at the times I have recorded, than in Mr. Stone's words which convey the last instructions of the Committee.

"At ingress, if *a*, *c*, *b*, are three small portions of the solar disc of which *c* is the nearest to the point of contact, and the illumination at *a* and *b* is undisturbed by the contact, then we say watch *a*, *c*, *b*, and when *c* is last seen to be as dark as the outer edge of the planet, give us the time as accurately as you can."

"But, if, although *c* has ceased to be as dark as the outer edge of the planet, yet the illumination of *c* is distinctly and clearly less than the illumination at *a* and *b*, still watch for last time at which you are perfectly certain that the illumination at *c* is less than at *a* or *b*."

According to this definition.

At signal 3, *c* became decidedly less dark than the outer edge of the planet. To prevent misunderstanding I should add that I am not certain that the ligament was ever as dark as the outer edge of the planet, the atmosphere of the planet possibly preventing this being so. But at signal 3, there was a well-marked change of colour at the point of contact such as one sees in the model immediately after "model" geometrical contact.

At signal 4, the illumination of *c* ceased to be distinctly and clearly less than the illumination at *a* and *b*.

Collecting the times relating to the contacts, we have—

	h.	m.	s.		h.	m.	s.	
1. First seen - -	20	9	47*	by Dent.	1	9	5*	by Molyneux.
2.	20	28	54	"	1	28	0	"
3. Ligament changing colour - -	20	29	29	"	1	28	34	"
4. Disappearance of any continuous ligament	20	29	48	"	1	28	54	"

...therefore get for times of contacts, taking mean of times given by the two chrono-...pt for "first seen" where the two times differ 10s. (nearly). (In this case ... that by Mr. Gamble with Dent, has been used.)

* These times differ nearly 10s.

INGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	7	7·67	3	6	8·70	1	52	13·96
2.	20	26	15·10	3	25	13·00	2	11	18·26
3.	20	26	49·64	3	25	47·44	2	11	52·70
4.	20	27	9·17	3	26	6·92	2	12	12·18

Whence the equations—

$$
\begin{array}{ll}
1. & 4''\!\cdot\!933 = -\,1{\cdot}658\,\delta\pi - \delta R - \delta\rho + 0{\cdot}525\,\delta\alpha + 0{\cdot}823\,\delta\Delta - 0{\cdot}054\,\delta t \\
2. & 0{\cdot}895 = -\,1{\cdot}722\,\delta\pi - \delta R + \delta\rho + 0{\cdot}483\,\delta\alpha + 0{\cdot}852\,\delta\Delta - 0{\cdot}051\,\delta t \\
3. & 2{\cdot}664 = -\,1{\cdot}723\,\delta\pi - \delta R + \delta\rho + 0{\cdot}482\,\delta\alpha + 0{\cdot}853\,\delta\Delta - 0{\cdot}051\,\delta t \\
4. & 3{\cdot}655 = -\,1{\cdot}724\,\delta\pi - \delta R + \delta\rho + 0{\cdot}411\,\delta\alpha + 0{\cdot}853\,\delta\Delta - 0{\cdot}051\,\delta t
\end{array}
$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. G. W. H. Maclear.

Observed with the 7-inch equatoreal; a first surface reflecting prism; power 184. Times noted by chronometer, Parkinson and Bouts 801. The times were taken by Mr. Coakes.

INGRESS.

Sky clear; definition not very good. The time of external contact not noted, my attention being directed to the driving clock of the equatoreal, which was not working steadily. I had also been instructed to confine myself to the internal contact.

At 3h. 58m. 49·5s. by chronometer I detected the faint outline of the external limb of Venus.

At 4h. 1m. 40s., the planet's external limb distinctly visible.

At 4h. 2m. 34s., the definition very bad, and image "furry," but I fancied an appearance of a brownish tinge upon the ligament.

4h. 3m. 13·5s. by chronometer; change of colour more apparent.

4h. 4m. 42s. by chronometer; decided change of colour.

4h. 5m. 25s. by chronometer; Venus appeared to separate from the ligament, traces of which still remain like broken threads at the Sun's limb.

4h. 6m. 2·5s. by chronometer. At this time all traces of the ligament disappeared.

Collecting the times relating to the contact we have—

		h.	m.	s.	
1.	Decided change of colour -	4	4	42	by chronometer.
2.	Venus appeared to separate from the ligament - - - -	4	5	25	,,
3.	All traces of ligament disappeared.	4	6	2·5	,,

The following corrections of the chronometer have been supplied by the Cape observatory—

	m.	s.		m.	s.
At	3	22·4	by chronometer; chronometer *fast* of local mean time	39	42·0
,,	4	19·0	,, ,, ,,	39	42·1

We therefore get for times of contact—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	4	4	42	20	26	1·99	3	24	59·93	2	11	5·19
2.	4	5	25	20	26	45·10	3	25	42·92	2	11	48·18
3.	4	6	2·5	20	27	22·71	3	26	20·42	2	12	25·68

[illegible]

Whence the equations —

$$
\begin{aligned}
1.\quad 0''\!.226 &= -1.721\,\delta\pi - \delta R + \delta\rho + 0.484\,\delta\alpha + 0.852\,\delta\Delta - 0.051\,\delta t \\
2.\quad 2.427 &= -1.723\,\delta\pi - \delta R + \delta\rho + 0.482\,\delta\alpha + 0.853\,\delta\Delta - 0.051\,\delta t \\
3.\quad 4.339 &= -1.724\,\delta\pi - \delta R + \delta\rho + 0.481\,\delta\alpha + 0.854\,\delta\Delta - 0.051\,\delta t
\end{aligned}
$$

Observations of the Contacts of the Sun and Venus.

Dr. W. L. Elkin.

Observed with half the object-glass of the heliometer of 4·2 inches aperture; power 180, and a bluish sunshade. The object-glass of the heliometer is, as a whole, extremely good, each image, however, formed by one-half of the object glass is, of course, deformed in the direction perpendicular to the line of section, and, as it was considered advisable to make use of but one of the images, care was taken to place this line parallel to that joining the centres of Venus and the Sun. Times noted by chronometer Gill.

Ingress.

The afternoon of December 6 was extremely warm and cloudless, but the definition very poor. The portion of the Sun's limb where Venus was to enter was placed in the square of wires marking the centre of the field, and at 20h. 4m. 58s. chronometer time a flattening of this point was perceived, which in seven or eight seconds proved itself by its permanency to have been caused by the advancing planet. In spite of the undulations I am inclined to consider the above time to be very little later than the true contact.

During the interval between this and internal contact, I devoted my attention principally to looking for signs of an atmosphere of Venus, but at no time could I detect any traces of such. The sky around the notch was perfectly black, as black as Venus herself, and by no effort could I see anything outside the Sun, which I would not immediately have pronounced to be subjective.

I took the second from the chronometer at 20h. 24m. 0s., and at 20h. 24m. 39s. chronometer time, I estimated that the prolonged limbs of Venus and the Sun would, in my opinion, have been tangential; this is, I believe, the so-called geometrical contact, but I can place no reliance on the moment noted, for, at that time, the distance between the blunted cusps of light was still one-third of the planet's diameter, and the imaginary prolongation of a curved line through such a distance is doubtless open to large systematic error. The progress of the phenomenon was then to my eye as follows :—The connection or ligament between Venus and the Sun, I must describe it as such since the apparent circular outline of the former was quite within the latter, which, at the moment above given, was quite as black as the planet, became gradually less deep in tint, diminished in extent, and the cusps lost their rounded-off appearance, the ends of the ligament changing from a well-defined outline to a gradual melting away. There was no definite moment that could have been noted until 20h. 25m. 41s. chronometer time, when a well-marked phase occurred. The ligament from being a band some 10″ or 12″ long and about one-quarter as broad, variable in shade and constantly being mixed up by the undulations of the air with the adjacent darker portions of the planet and the sky, dwindled to a narrow connexion of very much lighter shade, and not more than a few seconds long, using the term in the same sense as before, where the meaning is evident. The transition was rapid, I should say, in almost less than one second, and reminded me vividly of a very similar phase in the artificial transit which the American party had with them, and I had seen before in Germany, corresponding, I believe, to an instant very close to the actual contact of the model. This narrow connexion now faded gradually away, vanishing at 20h. 25m. 54s. chronometer time, but it was not until a few seconds later that the space between the planet and the nearest Sun's limb seemed to me quite as bright as the rest of the Sun's surface, this space being tinged with yellow apparently until 20h. 25m. 59s. chronometer time.

The first impression which the completed observation left on my mind was the entire absence of any disturbing influence of an atmosphere of Venus, and a disappointment at seeing no signs of any such. If it proves to have been generally seen under circumstances of considerable atmospheric disturbance, I can only attribute

my failure to having used too dark a shade for the high power and small aperture, although this was the lightest at my disposal and quite as bright as the eye could support for any great length of time. For this same reason I am inclined to place very little value on the two last times noted, as the phenomena they purport to fix must depend greatly on the observer and absorbing medium employed. On the other hand, the well-marked phase at 20h. 25m. 41s., which I cannot imagine to be radically modified by the influence of any "halo" or "aureole" afforded the satisfaction of having seized upon something definite, and which, although previously somewhat sceptical as to the resemblance of the model phenomena to those of the actual transit, I immediately recognised as a salient feature of the former under similar circumstances of atmospheric perturbation.

Collecting the times, we have—

	h.	m.	s.	
1. External contact - - -	20	4	58	by chronometer.
2. Tangential contact - -	20	24	39	,,
3. Decided change in ligament -	20	25	41	,,
4. Narrow connexion vanished -	20	25	54	,,
5. Space between planet and Sun's limb as bright as remainder of Sun's surface - - -	20	25	59	,,

We therefore get for times of contacts—

INGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	6	14·66	3	5	15·84	1	51	21·10
2.	20	25	55·60	3	24	53·55	2	10	58·81
3.	20	26	57·59	3	25	55·37	2	12	0·63
4.	20	27	10·59	3	26	8·34	2	12	13·60
5.	20	27	15·59	3	26	13·32	2	12	18·58

Whence the equations—

$$
\begin{array}{lrcl}
1. & 2''\!\cdot\!087 & = & -1\cdot658\ \delta\pi - \delta R - \delta\rho + 0\cdot527\ \delta\alpha + 0\cdot821\ \delta\Delta - 0\cdot054\ \delta t \\
2. & -0\cdot105 & = & -1\cdot721\ \delta\pi - \delta R + \delta\rho + 0\cdot484\ \delta\alpha + 0\cdot851\ \delta\Delta - 0\cdot051\ \delta t \\
3. & 3\cdot063 & = & -1\cdot723\ \delta\pi - \delta R + \delta\rho + 0\cdot482\ \delta\alpha + 0\cdot853\ \delta\Delta - 0\cdot051\ \delta t \\
4. & 3\cdot720 & = & -1\cdot724\ \delta\pi - \delta R + \delta\rho + 0\cdot481\ \delta\alpha + 0\cdot853\ \delta\Delta - 0\cdot051\ \delta t \\
5. & 3\cdot983 & = & -1\cdot724\ \delta\pi - \delta R + \delta\rho + 0\cdot481\ \delta\alpha + 0\cdot853\ \delta\Delta - 0\cdot051\ \delta t
\end{array}
$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. J. Freeman.

Observed with a 3½-inch theodolite, diagonal eye-piece; power 74, times noted by chronometer Arnold 1167.

INGRESS.

At 2h. 46m.* 18s. by chronometer, I caught sight of first shading of light between limbs, lighter considerably than Venus, say a very dark brown tint or even darker; I believe this might have been detected earlier, but the boiling just then seemed at its worst.

At 2h. 46m.* 35s. by chronometer, I concluded that internal contact had taken place, as a few seconds before, I detected a few breaking up twists of wavy light; this again gave place to a steady well-defined very fine line of light, and the cusps or horns of the Sun, just at this instant, appeared to meet, and form a persistent and continuous ring of sunlight round the planet. This I took to be the actual time of contact.

Sky clear, with a light south-east breeze. Both Sun and planet boiling, with no interval of steadiness, but definition withal of a uniform character.

---

* 47m. in original altered to 46m. in Dr. Gill's report.

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	2	46*	18	20	26	54·28	3	25	52·07	2	11	57·33
2.	9	46*	35	20	27	11·34	3	26	9·08	2	12	14·34

Whence the equations—

$$1.\quad 2''\!\cdot\!891 = -1\cdot723\,\delta\pi \;-\delta R \;+\delta\rho \;+0\cdot482\,\delta\alpha \;+0\cdot853\,\delta\Delta \;-0\cdot051\,\delta t$$
$$2.\quad 3\cdot753 = -1\cdot724\,\delta\pi \;-\delta R \;+\delta\rho \;+0\cdot482\,\delta\alpha \;+0\cdot853\,\delta\Delta \;-0\cdot051\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. C. R. Pillans.

Observed with a 3½-inch equatoreal; power 120, with a yellow slide. Times noted by Mr. M. W. Theal by chronometer Barraud 618.

INGRESS.

The time of external contact at ingress was noted by a stop watch at 3h. 6m. 30s.; the watch was compared with the chronometer a few minutes before and found to agree. At the time given, I first saw a slight depression in the Sun's limb. I at once noted the time, and on examining it more closely, satisfied myself that it was Venus.

At 3h. 18m. 5s. by chronometer, I saw a ring of light round the planet outside the Sun's limb, which seemed to vary in brightness several times. The Sun's limb at this time was very steady, and Venus clearly defined.

At 3h. 19m. 40s. by chronometer, cusps began to form and then die away again, the definition at this time being very changeable and the Sun's limb very unsteady.

At 3h. 25m. 30s. by chronometer, the black drop was much longer and very unsteady just before the change of colour.

At 3h. 25m. 37s. by chronometer, the colour changed to a light yellowish brown, and remained so for a couple of seconds.

At 3h. 26m. 9s. by chronometer, there was a sudden break off of any shade and a clear opening appeared between Venus and the Sun; this was very clearly seen, the Sun's limb being very steady at the time.

Collecting the times relating to the contacts, we have—

		h.	m.	s.	
1.	External contact - - -	3	6	30	by chronometer.
2.	Black drop much longer - -	3	25	30	,,
3.	Change of colour - - -	3	25	37	,,
4.	Sudden break off of any shade -	3	26	9	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	3	6	30	20	7	34·08	3	6	35·04	1	52	40·30
2.	3	25	30	20	26	37·18	3	25	35·02	2	11	40·28
3.	3	25	37	20	26	44·20	3	25	42·02	2	11	47·28
4.	3	26	9	20	27	16·29	3	26	14·02	2	12	19·28

Whence the equations—

$$1.\quad 6''\!\cdot\!342 = -1\cdot658\,\delta\pi \;-\delta R \;-\delta\rho \;+0\cdot524\,\delta\alpha \;+0\cdot823\,\delta\Delta \;-0\cdot054\,\delta t$$
$$2.\quad 2\cdot014 = -1\cdot723\,\delta\pi \;-\delta R \;+\delta\rho \;+0\cdot483\,\delta\alpha \;+0\cdot852\,\delta\Delta \;-0\cdot051\,\delta t$$
$$3.\quad 2\cdot382 = -1\cdot723\,\delta\pi \;-\delta R \;+\delta\rho \;+0\cdot482\,\delta\alpha \;+0\cdot853\,\delta\Delta \;-0\cdot051\,\delta t$$
$$4.\quad 4\cdot015 = -1\cdot724\,\delta\pi \;-\delta R \;+\delta\rho \;+0\cdot481\,\delta\alpha \;+0\cdot853\,\delta\Delta \;-0\cdot051\,\delta t$$

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* 47m. in original; altered to 46m. in Dr. Gill's report.

OBSERVATIONS of the CONTACTS of the SUN AND VENUS.

Captain M. Jurisch.

Observed with a $2\frac{1}{2}$-inch telescope by Reinfelder and Hertel, München; power 135. The telescope shows β Orionis as a double star; on nights of good definition Saturn's rings can be seen, consisting of two, and the rice grains on the Sun are visible on days of good definition. Times noted by chronometer Murray 753.

INGRESS.

At 3h. 7m. 0s. by chronometer, I first noticed the planet, flattening as it were, the protruding parts of the somewhat agitated limb of the Sun at the exact spot at which I expected the planet to appear on the Sun's limb. I think this record of the time of external contact will not be late by more than five or six seconds.

3h. 25m. 35·5s. by chronometer. The disc of the planet, mentally completed, seems to touch the limb of the Sun. The black space between the cusps presents an appearance as if some black liquid were filling the thinnest parts of the cusps by adhesion to both the planet's and the Sun's limbs.

3h. 26m 1s. by chronometer. The space between the cusps changes its black colour into a brownish tinge.

3h. 26m. 17·5s. by chronometer. Disappearance of any marked and persistent discontinuity in the illumination of the Sun's limb. This time record may be three or four seconds late, since I was doubtful for three or four seconds whether there was, or was not, discontinuity; the brownish tinge between the cusps becoming gradually brighter.

The chronometer correction as supplied in Dr. Gill's report is—

At 3h. 47·7m. by chronometer. Chronometer *fast* of local mean time 2·5s.
No rate given.

We therefore get for the preceding contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	3	7	0	20	7	56·60	3	6	57·50	1	53	2·76
2.	3	25	35·5	20	26	35·15	3	25	33·00	2	11	38·26
3.	3	26	1	20	27	0·73	3	25	58·50	2	12	3·76
4.	3	26	17·5	20	27	17·27	3	26	15·00	2	12	20·26

Whence the equations—

$$\begin{array}{lrl}
1. & 7''{\cdot}546 = & -1{\cdot}658\,\delta\pi \;-\delta R \;-\delta\rho \;+0{\cdot}523\,\delta\alpha \;+0{\cdot}824\,\delta\Delta \;-0{\cdot}054\,\delta t \\
2. & 1{\cdot}914 = & -1{\cdot}723\,\delta\pi \;-\delta R \;+\delta\rho \;+0{\cdot}483\,\delta\alpha \;+0{\cdot}852\,\delta\Delta \;-0{\cdot}051\,\delta t \\
3. & 3{\cdot}216 = & -1{\cdot}724\,\delta\pi \;-\delta R \;+\delta\rho \;+0{\cdot}482\,\delta\alpha \;+0{\cdot}853\,\delta\Delta \;-0{\cdot}051\,\delta t \\
4. & 4{\cdot}063 = & -1{\cdot}724\,\delta\pi \;-\delta R \;+\delta\rho \;+0{\cdot}481\,\delta\alpha \;+0{\cdot}853\,\delta\Delta \;-0{\cdot}051\,\delta t
\end{array}$$

STRAIT OF MAGELLAN.—STRAIGHT-ARM STATION, PECKETT HARBOUR.

		h.	m.	s.
Longitude of station	- -	4	43	13·65 W. of Greenwich.
Latitude ,,	- -	52°	46′	27″·0 S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Captain W. J. L. Wharton, R.N.

Observed with a 4-inch refractor, Simms' detached No. 1 of the Royal Observatory, Greenwich; power 145. The definition of the instrument is by no means good. Sunspots were numerous a few days before the transit, and afforded an excellent test,

but on no occasion could I get a sharp image. I could see the mottling of the Sun's disc, but could scarcely say that the rice grains ever assumed any definite form, the image not being clear enough. On the day of the transit the Sun was as clear as possible, and I saw a bright mass of faculæ near the limb as distinctly as I saw anything with the telescope; powers of 200 and 79 were supplied, and an Airy eye-piece of power 145. As I found I could get the best definition with this latter, and as it was nearly of the power mentioned in the "Instructions to Observers," I used it for the observation. It was fitted with a neutral tint wedge. I used the same portion of the wedge that I had found by experiment beforehand gave the best tint to a clear Sun, *i.e.*, about one-third from the darker end, which is about the same degree of shade with which I am accustomed to observe the Sun on all occasions, and which gave a clear limb with no glare whatever. The telescope, as well as the one used by Lieut. Havergal, was mounted temporarily equatoreally, as the vertical slow motion was so coarse that I was greatly afraid of not being able to keep Venus in the centre of the field at the critical moment if it had to be used, whereas the other motion was both slow and steady. This arrangement greatly facilitated the observation. A small spot on the Sun served well for focussing. Times noted by chronometer Loseby 113, by Lieut. A. M. Field, R.N.

Ingress.

First saw Venus. External contact passed probably a minute, 2h. 0m. 26s. by chronometer.

Aureole first seen on following quarter of outer limb of Venus, 2h. 12m. 23s. by chronometer.

Aureole all round outer limb, 2h. 15m. 0s. by chronometer.

Geometrical contact nearly. Aureole visible in line with Sun's limb, 2h. 19m. 9·8s. by chronometer.

Last appearance of well marked and persistent discontinuity in illumination of Sun's limb, 2h. 19m. 39·0s. by chronometer.

Last distinct appearance of atmospheric tremor, 2h. 19m. 43·0s. by chronometer.

The aureole round Venus was very plain, but was not to me so well defined as in 1874, probably on account of the bad definition of the telescope.

At geometrical contact which was not well defined on account of the haziness of the aureole, the latter showed on the Sun's limb.

Instantly after Venus was apparently inside the Sun's limb, but a blackish haze joined the planet to the outer darkness. This haze remained of the same width near Venus, but at the Sun's limb the light of the cusps seemed to run in and join very rapidly. This meeting of the cusps I give as the critical phenomenon of last appearance of well-marked discontinuity of the Sun's limb, and should be correct to two seconds.

The haze remained a little longer, but attenuated in its apparent density, and seemingly connected to Venus only. The time I give of last atmospheric appearance, its duration may have been a few seconds greater.

Sun's edge good, but definition of telescope generally poor.

Eight seconds after ingress the Sun was clouded.

Venus on the Sun appeared perfectly round.

In the interval between ingress and egress there were sometimes many clouds, at others, clear sky. Just before egress there was a long nimbus, with a heavy fall of rain, but it moved on and left the sky perfectly clear.

Egress.

First appearance of slight atmospheric tremor, 7h. 57m. 46·7s. by chronometer.

First appearance of well-marked persistent discontinuity in the illumination of the Sun's limb, 7h. 58m. 17·8s. by chronometer.

Geometrical contact as at ingress, 7h. 58m. 36·0s. by chronometer.

External contact between 8h. 18m. 23·0s. and 8h. 18m. 27·0s, by chronometer.

The atmospheric tremor first noted was a faint one, and it lasted some time before any real discontinuity of the Sun's limb was detected.

The critical phenomenon was not quite so well-marked as at ingress, but is probably correct to two seconds.

Geometrical contact was not so well observed as at ingress, the aureole again interfering.

Sun's edge quiet, but definition poor. Clouds covered the Sun about two minutes after egress, and just opened to let me see the external contact.

The movement of Venus across the Sun's limb was markedly more rapid than in 1874, so much so that I have no hesitation in saying that the critical phenomenon was twice as easy to determine as it was in the last transit, though, perhaps, the knowledge of what to expect, and the recollection of the long lingering contact of 1874, may have helped to make the contrast greater than it really was.

I devoted my whole attention to the Sun's limb near the point of contact, to observe the critical phenomenon as defined in the "Instructions," and, though I noted both geometrical contacts and the last atmospheric tremor at ingress and the first at egress, the bad definition of the telescope rendered all very doubtful.

Collecting the times relating to the contacts, we have—

INGRESS.

	h.	m.	s.	
1. First seen - - - - -	2	0	26	by chronometer.
2. Geometrical contact nearly - -	2	19	9·8	,,
3. Last appearance of well marked and persistent discontinuity -	2	19	39·0	,,
4. Last distinct appearance of atmospheric tremor - - -	2	19	43·0	,,

EGRESS.

	h.	m.	s.	
5. First appearance of slight atmospheric tremor - - -	7	57	46·7	by chronometer.
6. First appearance of well marked and persistent discontinuity -	7	58	17·8	,,
7. Geometrical contact as at ingress -	7	58	36·0	,,
8. External contact between these times - - - -	8	18	18·0	,,
	8	18	23·0	

We therefore get for times of contacts—

INGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	14	13	29·54	21	12	30	1	55	43·65
2.	14	32	16·62	21	31	14	2	14	27·65
3.	14	32	45·90	21	31	43·20	2	14	56·85
4.	14	32	49·91	21	31	47·20	2	15	0·85

EGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
5.	20	11	48·95	3	9	50·70	7	53	4·35
6.	20	12	20·13	3	10	21·80	7	53	35·45
7.	20	12	38·38	3	10	40·00	7	53	53·65
8.	20	32	23·61	3	30	22·00	8	13	35·65
	20	32	28·62	3	30	27·00	8	13	40·65

Whence the equations—

INGRESS.

$$1.\quad 6''\!\cdot\!864 = -0\cdot625\,\delta\pi - \delta R - \delta\rho + 0\cdot536\,\delta\alpha + 0\cdot814\,\delta\Delta - 0\cdot054\,\delta t$$
$$2.\quad 1\cdot840 = -0\cdot745\,\delta\pi - \delta R + \delta\rho + 0\cdot496\,\delta\alpha + 0\cdot843\,\delta\Delta - 0\cdot051\,\delta t$$
$$3.\quad 3\cdot339 = -0\cdot749\,\delta\pi - \delta R + \delta\rho + 0\cdot495\,\delta\alpha + 0\cdot844\,\delta\Delta - 0\cdot051\,\delta t$$
$$4.\quad 3\cdot549 = -0\cdot749\,\delta\pi - \delta R + \delta\rho + 0\cdot495\,\delta\alpha + 0\cdot844\,\delta\Delta - 0\cdot051\,\delta t$$

EGRESS.

$$
\begin{array}{lllllll}
5.\ 6''\cdot161 = 0\cdot436\,\delta\pi & +\,\delta R & -\,\delta\rho & +0\cdot830\,\delta\alpha & -0\cdot438\,\delta\Delta & -0\cdot052\,\delta t \\
6.\ 7\cdot769 = 0\cdot440\,\delta\pi & +\,\delta R & -\,\delta\rho & +0\cdot831\,\delta\alpha & -0\cdot436\,\delta\Delta & -0\cdot052\,\delta t \\
7.\ 8\cdot713 = 0\cdot443\,\delta\pi & +\,\delta R & -\,\delta\rho & +0\cdot831\,\delta\alpha & -0\cdot435\,\delta\Delta & -0\cdot052\,\delta t \\
8.{}^{*}7\cdot334 = 0\cdot615\,\delta\pi & +\,\delta R & +\,\delta\rho & +0\cdot851\,\delta\alpha & -0\cdot387\,\delta\Delta & -0\cdot054\,\delta t
\end{array}
$$

STRAIT OF MAGELLAN.—SANDY HILL STATION, PECKETT HARBOUR.

	h.	m.	s.
Longitude of station - -	4	43	4·35 W. of Greenwich.
Latitude „ - - -	52°	47′	23″·4 S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Lieut. A. Havergal, R.N.

Observed with a 4-inch refractor, Simms' detached No. 2 of the Royal Observatory, Greenwich; power 150. The lens of the telescope does not appear to be of the best quality, as it exhibits a great deal of colour in the Sun's limb. The eye-piece, the private property of the observer, gives excellent definition. "Rice grains" were clearly visible on the day of the transit, but with no definite form. The prismatic reflector and neutral tint wedge were used, the latter about a quarter of the way from its lightest end, and which remained unaltered during the observations. Times noted by pocket chronometer Molyneux 2097 by Lieut. H. B. Anson, R.N.

INGRESS.

Clouds prevented any observation.

EGRESS.

Slight disturbance on the outer limb of Venus without any definite shape, light yellowish haze, 6h. 45m. 29·6s. by chronometer.

Disturbance assumed a definite form or ligament, 6h. 49m. 39·2s. by chronometer.

First appearance of persistent and well marked discontinuity in the Sun's limb, 6h. 49m. 52·8s. by chronometer.

First appearance of aureole, 6h. 50m. 10s. by chronometer.

I consider the conditions satisfactory; a smart shower having fallen a few minutes before the time of contact, the surrounding atmosphere was clear, and the definition good.

My impressions of the approach of the contact were those of being agreeably disappointed at finding so little "boiling" or atmospheric tremor, and this is perhaps more remarkable as I used a lighter part of the wedge than I originally intended, having, in my anxiety not to miss any phase in the phenomenon, omitted to move it to a darker portion after the Sun came out from the clouds.

The "slight disturbance" (6h 45m. 29·6s.) was when I first noticed the appearance of a light brown and yellowish haze on the outer limb of Venus, which took place, roughly speaking, when she was about her own diameter within the Sun's limb; it had no definite form, but seemed to increase in extent as the planet approached the point of contact until 6h. 49m. 39·2s., when a light, band or ligament formed, through which, however, the sunlight was distinctly visible, and the limbs of both Sun and planet continuous. This ligament continued to get darker, and at 6h. 49m. 52·8s. I considered that a "well marked and persistent discontinuity" was first established, and is the only time I should give for contact were I restricted to a single term.

The aureole first appeared immediately after the limb of the planet had passed that of the Sun; it did not appear to me steady, but as intermittent flashes of sunlight.

The external contact was obscured by clouds.

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* Mean of times.

Collecting the times relating to the contacts, we have—

EGRESS.

	h.	m.	s.	
1. Disturbance assumed a definite form or ligament - -	6	49	39·2	by chronometer.
2. First appearance of "persistent discontinuity" - - -	6	49	52·8	,,

We therefore get for times of contacts—

EGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	12	8·57	3	10	10·30	7	53	14·65
2.	20	12	22·21	3	10	23·90	7	53	28·25

Whence the equations—

$$1.\quad 6''\!\cdot\!689 = 0\cdot437\,\delta\pi + \delta R - \delta\rho + 0\cdot830\,\delta\alpha - 0\cdot437\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 7\cdot398 = 0\cdot439\,\delta\pi + \delta R - \delta\rho + 0\cdot830\,\delta\alpha - 0\cdot437\,\delta\Delta - 0\cdot052\,\delta t$$

BARBADOS.—HASTINGS.

	h.	m.	s.	
Longitude of station - -	3	58	22·85	W. of Greenwich.
Latitude ,, - -	13°	4′	25″·9	N.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. C. G. Talmage.

Observed with a 6-inch equatoreal by Cauchoix; power 158. Times noted by clock Dent 2017.

INGRESS.

When bisected, limb of Venus surrounded by a white light, 15h. 9m. S.T.

15h. 17m. 40s. by clock. Venus entirely visible on and off the Sun; white light round following limb.

15h. 24m. 55·2s. by clock. The time of last appearance of a well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun.

This time I consider exact. Definition good; no black drop, and phenomenon was instantaneous.

The granular markings on the Sun were clearly visible all the morning.

(Clock comparison follows.)

I attempted no double-image micrometer observations. Many clouds were flying about, and I determined to run no risk.

Barometer 30·10 inches; Thermometer 86°·5 F.

There was not the slightest appearance of any contact after time given.

EGRESS.

At 20h. 43m. I noticed a bright gold (?) coloured mark on the following limb of Venus.

20h. 51m. 14s. by clock. Limbs boiling violently. Quite sharp; different from model when Sun's east, more like model Sun west. (I mean by this that at Oxford the appearances were different when Sun shone on or was behind model).

20h. 57m. 0s. Sunlight much more visible on N. than on S. limb of Venus; called Thomson's attention to this.

21h. 11m. 41s. by clock. Limbs boiling violently. I consider this time doubtful to three or four seconds. It was the most difficult observation of the series. Clouds constantly passing, but at the moment the Sun was quite clear. The Sun was over the sea, and we had to look through the heated air of the town.

Collecting the times relating to the contacts, we have—

INGRESS.

		h.	m.	s.	
1.	Persistent discontinuity - -	15	24	55·2	by clock.

EGRESS.

		h.	m.	s.	
2.	Internal contact - - - -	20	51	14	by clock.
3.	Last contact - - - -	21	11	41	„

We therefore get for times of contacts—

INGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	15	24	55·2	15	24	44·04	22	23	40·18	2	22	3·03

EGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
2.	20	51	14	20	50	59·08	3	49	1·77	7	47	24·62
3.	21	11	41	21	11	25·98	4	9	25·32	8	7	48·17

Whence the equations—

INGRESS.

$$1. \quad 1''\!\cdot\!631 = 1\cdot843\,\delta\pi - \delta R + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot863\,\delta\Delta - 0\cdot050\,\delta t$$

EGRESS.

$$2. \quad 8''\!\cdot\!122 = -2\cdot571\,\delta\pi + \delta R - \delta\rho + 0\cdot815\,\delta\alpha - 0\cdot469\,\delta\Delta - 0\cdot050\,\delta t$$

$$3. \quad 6\cdot902 = -2\cdot641\,\delta\pi + \delta R + \delta\rho + 0\cdot839\,\delta\alpha - 0\cdot417\,\delta\Delta - 0\cdot053\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Lieut. J. H. Thomson, R.A.

Observed with a 6-inch Simms' equatoreal, positive eye-piece; power about 180. Times noted by clock Dent 2016.

INGRESS.

Owing to passing clouds and bad definition I did not see Venus on the Sun's disc until 15h. 5m. 12·0s. by clock Dent 2016. External contact had then taken place about 75s., judging from the time taken by the planet at egress in passing from a similar phase to external contact. As Venus advanced on the limb of the Sun I had to be continually moving the wedge in order to retain a constant brightness of the field. At 15h. 20m. 49s., when the field suddenly increased in brightness, I saw the whole circumference of Venus, the limb outside the Sun's disc being surrounded by a beautiful halo of white light and sharply defined. At about the same time the cusps appeared slightly blunted and bent outwards. As interior contact approached the Sun cleared, and in a moment of good definition I saw geometrical contact at 15h. 24m. 24·0s. by clock. Immediately after this clouds began to pass, and there was a great deal of boiling and dancing. There seemed to be a discontinuity in the illumination of the Sun's limb for upwards of a minute after, but it did not seem as

dark as the disc of the planet. At about 15h. 25m. 30s. the Sun was completely obscured, and at 15h. 25m. 58s., when it reappeared, Venus was completely on its disc, being distant from the limb about the interval of the broader of the two pairs of wires in my eye-piece.

Egress.

At egress there was less trouble from the clouds, and the definition was better, although the Sun was lower. I first saw a well-marked and persistent discontinuity in the illumination of the Sun's limb near the point of contact at 20h. 50m. 24·0s. by clock. At 20h. 50m. 38·0s. this became as dark as the disc of the planet, and geometrical contact occurred at the same time. After interior contact light was visible round the outer limb for some time, but it did not completely surround the planet, extending further on the northern side than on the southern. The cusps appeared bent out, but not so much blunted as at ingress.

Exterior contact was very good. I last saw the planet at 21h. 11m. 15·0s. by clock.

Collecting the times relating to the contacts, we have—

Ingress.

	h.	m.	s.	
1. First seen - - - - -	15	5	12·0	by clock.
2. Apparent geometrical contact - -	15	24	24·0	,,

Real internal contact lost through clouds.

Egress.

	h.	m.	s.	
3. Persistent discontinuity - -	20	50	24·0	by clock.
4. Geometrical contact, shadow as black as planet - - - -	20	50	38·0	,,
5. Exterior contact - - - -	21	11	15·0	,,

We therefore get for times of contacts—

Ingress.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	15	5	12·0	15	5	27·59	22	4	26·89	2	2	49·74
2.	15	24	24·0	15	24	39·60	22	23	35·75	2	21	58·60

Egress.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
3.	20	50	24·0	20	50	39·82	3	48	42·56	7	47	5·41
4.	20	50	38·0	20	50	53·82	3	48	56·52	7	47	19·37
5.	21	11	15·0	21	11	30·84	4	9	30·16	8	7	53·01

Whence the equations—

Ingress.

$$1.\quad 6''\!\cdot\!566 = 1\cdot929\,\delta\pi - \delta R - \delta\rho + 0\cdot511\,\delta\alpha + 0\cdot833\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 1\cdot417 = 1\cdot843\,\delta\pi - \delta R + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot863\,\delta\Delta - 0\cdot050\,\delta t$$

Egress.

$$3.\quad 7''\!\cdot\!155 = -2\cdot571\,\delta\pi + \delta R - \delta\rho + 0\cdot815\,\delta\alpha - 0\cdot470\,\delta\Delta - 0\cdot050\,\delta t$$
$$4.\quad 7\cdot859 = -2\cdot571\,\delta\pi + \delta R - \delta\rho + 0\cdot815\,\delta\alpha - 0\cdot469\,\delta\Delta - 0\cdot050\,\delta t$$
$$5.\quad 7\cdot155 = -2\cdot641\,\delta\pi + \delta R + \delta\rho + 0\cdot839\,\delta\alpha - 0\cdot416\,\delta\Delta - 0\cdot053\,\delta t$$

JAMAICA.—UP PARK CAMP.

	h.	m.	s.	
Longitude of station - - -	5	7	8·35	W. of Greenwich.
Latitude ,, - - - -	17°	59′	25″·4	N.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

R. Copeland Ph. D.

Observed with a 6-inch Simms' equatoreal with a negative eye-piece; power 160. Times noted by chronometer Walker 171.

INGRESS.

At 19h. 4m. 9·0s. by chronometer, just perceptible notch in the Sun's limb. One minute later the notch was very deep. Aureole brighter to S. very obviously so at 19h. 15m.

Intense aureole at 19h. 22m. 30·0s.

Nothing like contact so early as 19h. 24m. 25·0s.

First steady flow of light between limbs at 19h. 24m. 35·0s. by chronometer.

At 19h. 24m. 49·0s. very wide lane.

Nothing like a ligament.

The unsteadiness of the images produced a black lenticular figure just at the point of ingress.

At 19h. 35m. by chronometer, the following remarks were added in amplification of the above.

Up to 19h. 24m. 25·0s. nothing that could in any way be confounded with internal contact had taken place. The bright line or aureole round Venus was indeed visible, but it was not nearly so bright as the Sun's disc. At 19h. 24m. 25s., or a second or two later, a certain regularity in the undulations of the image of Venus set in and produced a dark lenticular figure just at the point of contact; this interfered in some degree with the regularity of the phenomenon, but still the first flow of the direct Sun's light round Venus could be set down as occurring at 19h. 24m. 35·0s. by chronometer. This time was entered as that of internal contact. 19h. 24m. 49·0s. is merely set down as an epoch most certainly after the contact. Nothing presenting the appearance of a ligament was seen.

EGRESS.

At 0h. 12m. (by chronometer) clouds came over; the Sun cleared fairly at 0h. 33m.

	h.	m.	s.		
Up to	0	50	0·0	(by chronometer).	Line of light very distinct.
,,	0	50	7·0	,,	Line of light uncertain.
,,	0	50	9·0	,,	Line of light gone.

At 0h. 50m. 29·0s. by chronometer, the aureole was seen very considerably bulged out, so that contact was certainly over. Had I not known the nature of the aureole I might possibly have set the contact somewhat later; but, as matters stand, I believe 0h. 50m. 9s. by chronometer to be a reliable observation of contact.

(The above was written before 1h. by chronometer.)

At 1h. 0m. 0s. aureole very distinct on S. side through an arc of 60°, nearly touching Sun at one end and running out into a bright point at the other.

From 1h. 4m. to 1h. 9m. aureole was seen as a detached arc.

1h. 10m. 33s. by chronometer last contact seen as persistent indentation amongst the ripples on the limb.

1h. 11m. 30s. aureole still seen, then lost sight of it, and could not find it again. Width of aureole about 1″.

The aureole was best seen with the pale end of the wedge, but it was nevertheless visible through even the dark end of the wedge.

Collecting the times relating to the contacts, we have—

INGRESS.

	h.	m.	s.	
1. First notch in Sun's limb - - - -	19	4	9·0	by chronometer.
2. First flow of the direct Sun's light round Venus - - - - -	19	24	35·0	,,

EGRESS.

	h.	m.	s.	
3. Line of light gone (the aureole only remaining) - - - -	0	50	9·0	by chronometer.
4. Last contact - - - - -	1	10	33·0	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	19	4	9·0	13	57	2·87	20	56	2·11	2	3	10·46
2.	19	24	35·0	14	17	28·94	21	16	24·83	2	23	33·18

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
3.	0	50	9·0	19	43	3·21	2	41	5·76	7	48	14·11
4.	1	10	33·0	20	3	27·33	3	1	26·53	8	8	34·88

Whence the equations—

INGRESS.

$$1.\quad 4''\!\cdot\!539 = 2\cdot278\,\delta\pi - \delta R - \delta\rho + 0\cdot514\,\delta\alpha + 0\cdot831\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 2\cdot941 = 2\cdot195\,\delta\pi - \delta R + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot862\,\delta\Delta - 0\cdot050\,\delta t$$

EGRESS.

$$3.\quad 8''\!\cdot\!119 = -2\cdot295\,\delta\pi + \delta R - \delta\rho + 0\cdot814\,\delta\alpha - 0\cdot472\,\delta\Delta - 0\cdot050\,\delta t$$
$$4.\quad 7\cdot068 = -2\cdot384\,\delta\pi + \delta R + \delta\rho + 0\cdot838\,\delta\alpha - 0\cdot420\,\delta\Delta - 0\cdot053\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Captain G. Mackinlay, R.A.

Observed with a 6-inch equatoreal; power used 163. Times noted by mean time clock Dent 2010.

INGRESS.

Watched for and saw an indentation of the limb of the Sun among the slight ripples on its edge. Waited some 10 seconds to make quite sure that it was really caused by the planet, and that it was not mere tremor; saw it gradually increase in size. Time of first observing this 20h. 56m. 40s. by clock.

At 21h. 4m. light round the south pole; about 21h. 8m. light stealing all round. Light distinctly seen all round at 21h. 10m. 20s.

At 21h. 16m. 40s. nearly "contact," when I gave a tap to Bombardier McCulloch to make sure of the minutes, after this time, when limbs of Sun and Venus were first clear of each other. When there was first a permanent discontinuity between the two 21h. 17m. 0s. by clock. This last I considered "internal contact." No black drop, but a gradual shading round Venus at contact, when limbs of Sun and planet were clear of each other; both were perfectly sharp and defined.

EGRESS.

First permanent attachment of limbs of Sun and planet observed at 2h. 41m. 49s. by clock. This I considered "internal contact." Appearances similar to those at

internal contact at ingress, but definition not so good, limbs of Sun and planet quivering, not so much of the shading or illuminated atmosphere round Venus visible as at ingress.

At 2h. 49m. aureole appeared. At 2h. 56m. aureole seen faintly only if light part of the wedge is used; not half round planet; one-third way round.

Last appearance of the following limb of Venus among the ripples on the edge of the Sun observed at 3h. 2m. 3s. by clock. Possibly it vanished three or four seconds before, but this is the best estimate I can give; the limb of the Sun quivered a good deal, but I believe I traced the indentation caused by the planet as long as stated.

I purposely refrained from giving several times at each contact so as to avoid possible confusion. The internal contacts did not resemble the model, except in their lingering nature.

At ingress clear uncloudy sky; definition good; granulations of Sun visible. Half an hour before egress a few clouds crossed the Sun, but cleared off, leaving the sky clear; definition however not so good as at ingress, and granulations not easily visible.

At ingress, egress, and also two days after in the transit instrument, it was noted that the south pole is illuminated.

The planet appeared quite round; no satellite seen.

The clock driving the hour circle failed to act shortly before egress, but the R.A. slow motion screw was used to follow the Sun and planet.

Collecting the times relating to the contacts, we have—

INGRESS.

	h.	m.	s.	
1. An indentation in the Sun's limb - -	20	56	40	by clock.
2. Permanent discontinuity - -	21	17	0	,,

EGRESS.

	h.	m.	s.	
3. First permanent attachment of limbs of Sun and planet - - - - -	2	41	49	by clock.
4. Last appearance of Venus among the ripples on the Sun's edge - -	3	2	3	,,

We therefore get for times of contacts—

INGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	56	40	13	56	52·69	20	55	51·96	2	3	0·31
2.	21	17	0	14	17	16·08	21	16	12·00	2	23	20·35

EGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
3.	2	41	49	19	42	58·44	2	41	1·00	7	48	9·35
4.	3	2	3	20	3	15·69	3	1	14·93	8	8	23·28

Whence the equations—

INGRESS.

$$1.\quad 4''\!\cdot\!009 = 2\cdot278\,\delta\pi - \delta R - \delta\rho + 0\cdot514\,\delta\alpha + 0\cdot830\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 2\cdot310 = 2\cdot196\,\delta\pi - \delta R + \delta\rho + 0\cdot468\,\delta\alpha + 0\cdot862\,\delta\Delta - 0\cdot050\,\delta t$$

EGRESS.

$$3.\quad 7''\!\cdot\!888 = -\,2\cdot295\,\delta\pi + \delta R - \delta\rho + 0\cdot814\,\delta\alpha + 0\cdot472\,\delta\Delta - 0\cdot050\,\delta t$$
$$4.\quad 6\cdot445 = -\,2\cdot384\,\delta\pi + \delta R + \delta\rho + 0\cdot838\,\delta\alpha + 0\cdot420\,\delta\Delta - 0\cdot053\,\delta t$$

JAMAICA.—CHERRY GARDEN, NEAR KINGSTON.

The longitude of the station obtained from two comparisons of Dr. Pearson's chronometer with the Up Park camp sidereal clock makes the Cherry Garden station 0·90s. E. of Up Park camp.

The longitude is therefore—

$$\overset{\text{h.}}{5}\ \ \overset{\text{m.}}{7}\ \ \overset{\text{s.}}{7 \cdot 45} \text{ W. of Greenwich.}$$

The latitude was determined by meridian altitudes of the Sun, α Piscis Australis and α Eridani, though from the nature of the instrument not with any great precision, and verified by the known distance from the lighthouse, a few miles to the E. of Port Royal, bearing one degree (true) East of South, at a distance of about seven miles. The observations vary between 18° $2\frac{1}{4}'$ and 18° $3\frac{3}{4}'$ N., giving most weight to the stars; the adopted latitude is—

$$18^{\circ}\ 3'\ 20'' \text{ N.}$$

Observations of the Contacts of the Sun and Venus.

Dr. J. B. Pearson.

Observed with a $3\frac{1}{2}$-inch telescope by Secretan of Paris, coated on the inner side with a silver film, which was found quite sufficient to reduce the brightness of the Sun, when employed as it was with a diagonal eye-piece. The mounting, eye-pieces, and micrometer were by Simms, and I can take no exception to any part of the instrument. Unfortunately, I did not receive in time an eye-piece, power 120, constructed on principles designed to meet the difficulty under which I labour from shortness of sight, but I am not prepared to say that it would have actually removed the indistinctness which certainly I noticed with the power used, viz., 135, for which I cannot entirely account, but which I am sure was not enough to affect the apparent time of contact, at any rate more than two or three seconds, within which limit similarly situated observers seldom agree. I saw nothing like an atmosphere round Venus, though I looked carefully for it, possibly my telescope, considerably smaller than what I may call the authorised size, would not be large enough to show it. At the same time it is, as far as I can tell, tolerably achromatic. And I will take this opportunity of mentioning a phenomenon, possibly somewhat of a similar nature which I have observed here more than once. The sun can be seen to set behind a ridge of hills perhaps 30 miles distant. When viewed through the telescope at an elevation of about one degree above the crest of the hills, the lower limb is of an orange tint, the sides of the Sun's ordinary colour, and the upper limb green; these tints continuing as the two limbs successively disappear beyond the hills which are often quite free from any cloud or haze. I do not recollect having seen the phenomenon described in any book, nor am I sure of its explanation. (Times taken by a watch which Dr. Pearson held in his hand and which was compared with his standard chronometer directly after each contact.)

Ingress.

The first external contact I missed in a way which can be easily explained. Though constantly observing the Sun for altitude I have seldom examined its features, and so failed to notice that a point on its disc 145 E. of N. from the pole, the predicted place of contact would be at 9 a.m., slightly to the right, and not to the left of the lowest point of the Sun's limb. Having been indisposed for three days previously, and not willing to expose myself in observing, I had rather put my preparatory work aside and thus failed to look through the question in the way I might have done had I been quite ready for any kind of work.

When I saw Venus first she had intruded about one-third of her disc upon the Sun's sphere; I watched her carefully until the two limbs were very nearly in contact, from which time I did not remove my eye until the Sun's light appeared to surround the planet, the moment of this phenomenon I fixed at

$$\overset{\text{h.}}{1.\ 21}\ \ \overset{\text{m.}}{16}\ \ \overset{\text{s.}}{26} \text{ Local mean time,}$$

or perhaps two or three seconds later. I noticed no kind of black drop or sympathetic

attraction or assimilation between the limb of the planet and that of the Sun, or rather the edge of the atmosphere enclosing the Sun. If the want of definition from which my vision suffered, be it due to my own eyes, my eye-piece, or my object-glass, allows me to give any formulated description of the first internal contact, I should say, that when the planet was actually projected on the Sun's disc, say 20 seconds before the time I assign for actual contact, the surface of the planet adjoining the atmosphere began to be picked out with little white dots, commencing very probably from either side, but, as the phenomenon was new to me, I cannot say whether the white spots began at the two ends of the incomplete segment of the planets disc, or whether they began throughout at once. I cannot say that I saw two cusps of light gradually advancing until their points actually touched, but rather, as I have said, that the segment of the planet nearest to the atmosphere, and still obscure, began to be speckled with white dots, which in not more than 20 or 25 seconds at the outside developed into a white line.

When the planet was well advanced on the Sun's disc she was well-defined in her outline, and no remarkable difference presented itself at 10h. 52m. a.m., when I took a measure of her distance from the Sun's edge. But, at noon, when the distance of the centres of the Sun and Venus was the least, the irregularity of her disc, from the boiling of the surrounding solar light, was very marked, and had increased at 1h. 35m. p.m., when I think it was at its maximum.

Egress.

I had little or no hesitation as to the time of the second internal contact. Perhaps the outer edge of Venus was too disturbed to exhibit the minute spots which I seemed to observe in the morning. But still the planet seemed to descend fairly upon the atmosphere without any mutual attraction of any kind, and though the planet's disc did not then appear to the eye anything like a perfect curve or sphere the actual contact seemed extremely regular, and I do not think that I had any hesitation as to when it actually occurred, viz., at—

	h.	m.	s.	
2.	2	41	2	local mean time.

I was not so fortunate as I might have been in taking off the last external contact. Owing to a mishap to my chronometer in the morning, I depended for my time on my watch, which I held in my hand, but just before the last contact, through inadvertence, I had allowed the planet to get too near the edge of the telescope to be viewed as it should be, so I took hold of the slow motion handles to bring her more into the field of view; moving the telescope in this way causes a slight tremor in the telescope itself, and when this had passed off the indentation caused by the planet's disc on that of the Sun had all but disappeared, and I could not feel perfectly confident within two or three seconds when the actual disappearance was complete. Still, I am sure there can be no great error about the time I give—

	h.	m.	s.	
3.	3	1	15	local mean time,

as the vanishing segment of the planet had only a partial resemblance to the undulations on the edge of the Sun, especially as the momentary apprehensions which I felt do not seem justified by the result. Had the period I assumed between the third and fourth contacts been too long a mistake would be probable, but as it was 11 or 17 seconds shorter than the computed time, and, as I am sure that the Sun's disc had entirely recovered its normal outline at the time I noted, I think that my observation may be taken as generally exact. Moreover, the longer the period of transit the shorter will be the passage across the Sun's limb, and as my own period of transit is as long as that computed by the French and two minutes longer than that given in the Nautical Almanac, I may be satisfied with the fact that my passage across the disc is shorter than that anticipated by either of these authorities.

Collecting the preceding times, we have—

Ingress.

[illegible] Mean Time.		Local Sidereal Time.			Greenwich Mean Time.		
m.	s.	h.	m.	s.	h.	m.	s.
16	26	14	17	30·11	2	23	33·45

EGRESS.

	Local Mean Time.			Local Sidereal Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
2.	2	41	2	19	42	59·44	7	48	9·45
3.	3	1	15	20	3	15·76	8	8	22·45

Whence the equations—

INGRESS.

$$1.\ 2''\cdot942 = 2\cdot197\,\delta\pi \ -\delta R \ +\delta\rho \ +0\cdot467\,\delta\alpha \ +0\cdot862\delta\Delta \ -0\cdot050\delta t$$

EGRESS.

$$2.\ 7''\cdot893 = -2\cdot295\,\delta\pi \ +\delta R \ -\delta\rho \ +0\cdot814\,\delta\alpha \ -0\cdot472\delta\Delta \ -0\cdot050\delta t$$
$$3.\ 6\cdot403 = -2\cdot384\,\delta\pi \ +\delta R \ +\delta\rho \ +0\cdot838\,\delta\alpha \ -0\cdot420\delta\Delta \ -0\cdot053\delta t$$

JAMAICA.—KEMPSHOT OBSERVATORY, MONTEGO BAY.

The longitude of the station was obtained by determining telegraphically, on November 28 and 29, the difference between Kempshot Observatory at Montego Bay and Lord Rodney's statue, Dr. Copeland observing at the latter place.

Two chronometers were compared with the standard clock of the observatory, and then carried to the telegraph office at Montego Bay, signals were exchanged with Dr. Copeland by both chronometers, which were carried back to the observatory, and again compared. Unfortunately the weather was unfavourable at Montego Bay, no observations being obtained between November 29 and December 3, and the going of the standard clock most irregular; also some accident happened to one of the chronometers on November 29, so that the determination is not so reliable as could be wished. The result is—

	h.	m.	s.
Kempshot Observatory west of Lord Rodney's statue - -	0	4	18·83
Lord Rodney's statue west of Greenwich - - - -	5	7	10·65*

Therefore—

	h.	m.	s.
Kempshot Observatory is west of Greenwich - - -	5	11	29·48

The latitude supplied by Mr. Hall is—

$$18^\circ\ 24'\ 51''\ \mathrm{N}.$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. M. Hall.

Observed with a 4-inch equatoreal; power 200, with a first surface reflecting prism, and a sliding glass shade.

INGRESS.

The morning of December 6 was very fine. A little after 7 a.m. the equatoreal was pointed towards Venus, a low power, the first surface reflecting prism and a very light glass shade were used, but although a watch was kept until 15 minutes before external contact, yet nothing whatever was seen of the planet.

The low power was then changed for a power of 200, the sliding glass shade was adjusted to the eye-piece, and the focus was carefully obtained by means of the only distinct spot there was on the Sun's disc, the mottling of the surface was clearly seen, and the definition was noted as good. The telescope was then directed towards the point of contact.

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* Report of the Telegraphic Determination of differences of longitude in the West Indies and Central America by Lieut. Commander F. M. Green, U.S.N.

As the time of external contact approached, a cloud obscured the Sun, and when the cloud had so far passed away that the Sun was visible, the planet had made a notch in the limb, as represented in Fig. 1.

The sliding glass prism proved to be most useful, as it was pushed entirely aside for this observation.

The time noted by the clock corresponded to 20h. 51m. 51·46s., and watching the increment of the notch, I wrote down that the contact might have occurred 30 seconds earlier. Again the notch in the Sun's limb was 1·5″ according to Fig. 1, and as 1·5″ corresponds to an interval of 30 seconds, we may assume as the epoch of external contact 20h. 51m. 21·46s. local mean time with a probable error of less than 10 seconds.

When about half the body of the planet was upon the Sun's disc, there were faint indications of the other half outside the disc, the exterior half was seen projected against an illuminated background, and as this effect increased towards the Sun's limb, there is reason to suppose that the exterior half of the planet was seen projected against the solar corona.

But there was no appearance of any arc of light round the following limb of Venus until 21h. 4m. 19s. local mean time, or eight minutes before internal contact, when the light suddenly burst out at the two points where the disc of Venus was cut by the Sun's limb. From these two points the light spread rapidly outwards, and in about 10 seconds the exterior limb of the planet was completely illumined. This arc of light was of the same colour and brilliancy as the surface of the Sun near the centre of the disc, and consequently it was more brilliant than the surface of the Sun near the limb. When the planet was quite within the Sun's disc, it had a faint edging of light, but when the planet was at her nearest to the centre of the Sun this edging was hardly visible.

But still as internal contact approached, the arc of light could not be distinguished from direct sunlight, and, as there was no "black drop" or distortion of any kind, I began to fear I should see nothing to mark contact, but at length I saw a few interference lines, between the limbs of the Sun and planet, the planet being apparently wholly within the disc of the Sun. These lines were light brown in colour, parallel to the limbs, from 5″ to 10″ in length, and very tremulous.

The effect produced by these lines was noted as "shadow"; they were first seen at 14h. 12m. 56s. by clock. At 14h. 13m. 3s. by clock, they produced quite a strong shadow. At 14h. 13m. 10s. by clock, they had nearly disappeared, and at 14h. 13m. 28s. by clock there was nothing whatever to be seen of them.

Fig. 2 was drawn to represent the phenomena at 14h. 13m. 3s. when the interference lines were strong.

We may therefore take the epoch—

14h. 13m. 19s. by clock or 21h. 12m. 21·46s. local mean time;

as the time of the last appearance of any well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun near the point of contact, and this time is subject to a probable error of about four seconds.

A subsequent note was made that about 10 seconds before the shadow was seen, the planet appeared as in Fig. 2, Plate XIV., Transit of Venus 1874; but as the exterior arc of light was really brighter than in that drawing the phenomena are better represented by Fig. 3 of this report.

Egress.

As the time of egress approached, the definition became very bad, clouds were continually passing and there was much "boiling," the sliding glass shade was moved backwards and forwards continually, and often pushed aside altogether.

Under these circumstances the planet was seen to move up to the Sun's limb without any "black drop," distortion or interference lines, and at 2h. 36m. 25s. local mean time, when clouds entirely obscured the Sun, there was only a very narrow thread of light left, so narrow that I felt apprehensive that contact, as observed at ingress, had already passed.

The Sun appeared again at 2h. 36m. 48s., when it was seen that the preceding limb of Venus had advanced beyond the Sun's limb, as shown in Fig. 3.

If, therefore, we assume that the arc of light was a tangent to the Sun's limb at 2h. 36m. 25s., contact as observed at ingress must have occurred when the limb of the planet was about 1″ further from the limb of the Sun, or 20 seconds earlier. This gives as the time of internal contact 2h. 36m. 5s. local mean time.

Again, the notch seen at 2h. 36m. 48s. at egress appeared as large as the notch seen at ingress 33 seconds before contact, but the definition at egress was very bad, while that at ingress was very good, so that the notch must have been really larger at egress, say 0″·5 ; and this gives as the time of internal contact 2h. 36m. 5s. again. Hence we shall take as the epoch of internal contact at egress, 2h. 36m. 5s. local mean time, with a probable error of about five seconds.

Clouds prevented my seeing the exterior arc of light disappear, the arc was then five minutes after contact.

Clouds prevented me from making a better observation of the external contact than the following. At 2h. 56m. 16s. local mean time, the notch appeared as large as it did when first seen at ingress (Fig. 1), but it really must have been a good deal larger, say 1″, so that external contact must have occurred about 50 seconds afterwards, or at 2h. 57m. 6s. local mean time, with a probable error of at least 10 seconds.

Collecting the times, we have :—

INGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	13	52	46	13	52	52·25	20	51	51·46	2	3	20·94
2.	14	13	10	14	13	16·61	21	12	12·47	2	23	41·95
3.	14	13	19	14	13	25·61	21	12	21·46	2	23	50·94
4.	14	13	28	14	13	34·61	21	12	30·45	2	23	59·93

EGRESS.

No actual observation of contact.

Whence the equations—

$$
\begin{array}{ll}
1. & 4''\!\cdot917 = 2\cdot296\,\delta\pi - \delta R - \delta\rho + 0\cdot514\,\delta\alpha + 0\cdot831\,\delta\Delta - 0\cdot052\,\delta t \\
2. & 3\cdot203 = 2\cdot215\,\delta\pi - \delta R + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot862\,\delta\Delta - 0\cdot050\,\delta t \\
3. & 3\cdot643 = 2\cdot215\,\delta\pi - \delta R + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot862\,\delta\Delta - 0\cdot050\,\delta t \\
4. & 4\cdot083 = 2\cdot215\,\delta\pi - dR + \delta\rho + 0\cdot467\,\delta\alpha + 0\cdot862\,d\Delta - 0\cdot050\,\delta t
\end{array}
$$

BERMUDA.—GIBB'S HILL.

		h.	m.	s.	
Longitude of station	- -	4	19	20·45	W. of Greenwich.
Latitude ,,	- -	32°	14′	46″·6	N.

OBSERVATION of the CONTACTS of the SUN and VENUS.

Mr. J. J. Plummer.

Observed with a Cooke equatoreal of 6 inches aperture, Steinheil positive eye-piece ; power 177, and clock Dent 2015.

INGRESS.

Time of first external contact 14h. 43m. 48·0s. by clock, clouds passing at the time, estimated by further passage upon the limb to be late about 13 seconds. Contact observed without wedge,* but the faint end of the wedge was immediately brought into use to estimate the interval by which the time of observed external contact is too late.

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* Subsequently I am not quite sure of this fact, but changes from direct vision to the thin end of wedge had been frequent during the few minutes that contact was waited for.

At 14h. 47m. 20s. the aureole was seen all round Venus, but particularly brilliant in position *a* in figure.

At 14h. 51m. 30s. aureole does not seem to become more marked; expect no difficulty with it. (Later on it was more distinct, and was visible up to the instant of internal contact.)

	h.	m.	s.	
Geometric contact - - -	15	3	46	by Dent 2015.
a - - - - - -	15	3	59·5	,,
b - - - - -	15	4	13·5	,,

(Counting one second slow, *i.e.*, the seconds should be 47s., 60·5s., and 14·5s. respectively).

The first time is that of geometric contact; it is believed to be fairly accurate, that is to say, I do not think it is more than three seconds in error. The other phases came on quicker than was expected, but are observed to the satisfaction of the observer. The time marked "*a*" is that when sunlight was seen between the limbs of the Sun and planet, or it is the completion of the interval between the cusps by a grey or colourless haze distinct from (and greatly brighter than) the aureole (which was not troublesome), and distinct from the perfect and bright sunlight that filled the interval at the moment marked "*b*." The only drawback to the satisfactory character of the observation was that the Sun clouded immediately afterwards, and did not allow of that distinct verification after the occurrence that could have been wished. The illumination was carefully kept at the mean brightness by estimation as directed in the instructions, but the passing clouds rendered frequent changes of the wedge necessary.

EGRESS.

	h.	m.	s.	
a - - - - - -	20	27	58·0	by Dent 2015.
b - - - - -	20	28	14·5	,,
Geometric contact - - -	20	28	29·0	,,

Observed through dense cloud without wedge. Image very faint indeed, and observation wanting in the certainty obtained at ingress. There was much tremor of the limbs, both of Venus and the Sun. The times marked "*a*" and "*b*" are comparable with those marked "*b*" and "*a*" at ingress, but the utmost care was required to make them out; and nothing but the similar observations in the morning, which prepared the observer for these changes, would have led to their being seen at all.

	h.	m.	s.
Second external contact - -	20	48	25·5

This is the last time at which the planet was certainly seen on the disc, being at this moment nearer the true external contact than at the time marked for first external contact at ingress. The Sun having been mostly hidden between third and fourth contacts was brighter at this instant, though boiling greatly. The extreme thin end of the wedge was used.

I do not look upon this observation* as of any value unless confirmed, and the illumination was as far removed from the standard as possible, that is to say, the phenomenon was barely visible.

In further explanation of the phenomena observed at contact of Venus with the Sun's limb I wish to add† :—

1st. That the average width of the aureole was estimated at 1″, and the brighter portion had an estimated breadth of 1″·5. These were obtained with reference to the wires in the field, whose distance apart is supposed to be about 1″.

2nd. That the "black drop" or "ligament" connecting Venus with the region exterior to the Sun's limb was not at any time as dark as the body of the planet.

3rd. That the appearance of sunlight throughout the whole width between the cusps was a sudden and marked phenomenon, about which there could be no doubt. The time noted may be a trifle late (say half a second), as I was determined to be quite

* This remark applies to the internal contact at egress, and equally to the three times marked "*a*," "*b*," and geometric contact; the circumstances under which these times were noted being similar.

† These remarks are of a general character. They (with the exception of the fifth) refer entirely to the internal contact at ingress; the circumstances at egress allowed of no description of the minuter phenomena.

sure of its persistent character. Still, I am not disposed to recommend that any alteration should be made from the time set down.

4th. Between the times marked "*a*" and "*b*" there was a gradual diminution of intensity of shade on the so-called "black drop," so that it was far from being a conspicuous phenomenon towards the end of that interval. The time noted is that of the last moment when it was perceptible to me.

5th. Although much doubt exists with reference to the observations at egress for reasons already explained, the final or second external contact must be held to have been well observed, and is accurate to three or four seconds or possibly less. The ripples along the Sun's limb were seen to break against the dark disc of Venus for about half a minute before this time, after which they met with no obstacle.

N.B.—These notes were written on the following day. They are not intended to modify what was written down at the time, but merely to supply omissions and to call attention to the satisfactory character of the final* contact, which, owing to the disappointment of partial failure at internal contact, was not estimated at its true value at the time.

And we therefore get finally for times of contacts—

INGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1. First seen -	14	43	48·0	14	45	29·95	21	44	29·09	2	3	49·54†
2. Geometric contact -	15	3	47	15	5	28·89	22	4	24·75	2	23	45·20
3. *a* - -	15	4	0·5	15	5	42·39	22	4	38·22	2	23	58·67
4. *b* - -	15	4	14·5	15	5	56·39	22	4	52·18	2	24	12·63

EGRESS.

	Clock Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
5. *a* - -	20	27	58·0	20	29	39·64	3	27	42·39	7	47	2·84
6. *b* - -	20	28	14·5	20	29	56·14	3	27	58·84	7	47	19·29
7. Geometric contact -	20	28	29·0	20	30	10·64	3	28	13·30	7	47	33·75
8. Last external contact -	20	48	25·5	20	50	7·16	3	48	6·56	8	7	27·01

Whence the equations—

INGRESS.

$$
\begin{array}{llll}
1. & 4''\!\cdot\!984 = & 2\cdot455\,\delta\pi - \delta R - \delta\rho + 0\cdot507\,\delta\alpha + 0\cdot835\,\delta\Delta - 0\cdot052\,\delta t \\
2. & 1\cdot700 = & 2\cdot403\,\delta\pi - \delta R + \delta\rho + 0\cdot461\,\delta\alpha + 0\cdot867\,\delta\Delta - 0\cdot049\,\delta t \\
3. & 2\cdot371 = & 2\cdot402\,\delta\pi - \delta R + \delta\rho + 0\cdot460\,\delta\alpha + 0\cdot867\,\delta\Delta - 0\cdot049\,\delta t \\
4. & 3\cdot049 = & 2\cdot402\,\delta\pi - \delta R + \delta\rho + 0\cdot460\,\delta\alpha + 0\cdot867\,\delta\Delta - 0\cdot049\,\delta t
\end{array}
$$

EGRESS.

$$
\begin{array}{llll}
5. & 7''\!\cdot\!006 = & -2\cdot566\,\delta\pi + \delta R - \delta\rho + 0\cdot811\,\delta\alpha - 0\cdot477\,\delta\Delta - 0\cdot050\,\delta t \\
6. & 7\cdot819 = & -2\cdot567\,\delta\pi + \delta R - \delta\rho + 0\cdot812\,\delta\alpha - 0\cdot476\,\delta\Delta - 0\cdot050\,\delta t \\
7. & 8\cdot541 = & -2\cdot567\,\delta\pi + \delta R - \delta\rho + 0\cdot812\,\delta\alpha - 0\cdot476\,\delta\Delta - 0\cdot050\,\delta t \\
8. & 5\cdot373 = & -2\cdot593\,\delta\pi + \delta R + \delta\rho + 0\cdot836\,\delta\alpha - 0\cdot424\,\delta\Delta - 0\cdot053\,\delta t
\end{array}
$$

* The external contact at egress.

† Estimated by observer to be 13 seconds late.

Observation of the Contacts of the Sun and Venus.

Lieut. C. B. Neate, R.N.

Observed with 6-inch Naylor equatoreal; power about 180.

Ingress.

At 2h. 8m. 21s. by chronometer Arnold and Dent 715 I observed a fine light shading on Venus's following limb. I have nothing to remark about this, except that I estimate that I was three or four seconds late at least.

	h.	m.	s.	
(2)	2	28	4	by Arnold and Dent 715.
(3)	2	28	13	" "
(4)	2	28	32	" "
	2	28	34	

At time (2) I observed what apparently was geometrical contact. This I considered difficult to estimate. At time (3) I observed the band between Venus and the Sun (never quite as dark as Venus) change colour from dark to a dusky brown. This band gradually got lighter till time (4), when it trembled, wavered, and disappeared between 32s. and 34s.

When about half on the following limb of Venus appeared bright, but not so bright or the depth of the bright part so great as in 1874.

The first observation was made with the extreme light end of the wedge. All others were made with the wedge at the place marked; that is one that I had been accustomed to use for some days past.

Time (2), as I have before stated, was very difficult to estimate, and I do not consider it very reliable. Probably between (2) and (3) fleecy clouds crossing the Sun necessitated my continually adjusting the wedge to the varying conditions of light, but at (3) the Sun was perfectly clear of clouds.

The band between Venus and the Sun was at first uniform in colour, but never so dark as the body of the planet. I watched the band very attentively, and at the time recorded (3) it changed colour or got decidedly lighter, after which it got gradually lighter and diminished in breadth. At time (4) the band ceased to exist. The fact of the limb of Venus about the point of contact being bright did *not* disturb me or in any way interfere with my observation. I am confident the band disappeard at time (4), and there was uninterrupted sunlight between the limb of the Sun. Almost immediately after the Sun was almost obscured by clouds. I estimate the depth of the broadest part of the bright ring or aureole to have been about two in terms of the breadth between my fine wires.

Note made an hour afterwards—

Three or four seconds might possibly have included the phenomenon (4), but at the time I was under the impression that two only included it.

Egress.

	h.	m.	s.	
(5)	7	52	34	by Arnold and Dent 715.

This time is for an observation of an approximate geometrical contact; it was observed without any shade. Large masses of cloud had been passing the Sun for two or three hours before egress, and the Sun could only be seen through occasional openings. Through one opening I just caught sight of Venus on the Sun's limb, and she appeared to be in geometrical contact; but I cannot pretend to any great accuracy, not even within 10 seconds, in this observation.

	h.	m.	s.	
(6)	8	11	35	by Arnold and Dent 715.
	8	11	40	

At about 8h. 11m. 30s. the Sun shone brighter, and I could see a little bit of Venus distinctly; at 35s. I suspected she had left the Sun's limb, but a cloud passed across; at 8h. 11m. 40s. I was certain Venus had gone for good.

The Sun's limb was boiling and very agitated; definition otherwise fairly good. No aureole seen during egress.

[The fine wires were separated by about a second of arc.]

And we therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	2	8	21	14	45	36·49	21	44	35·61	2	3	56·06
2.	2	28	4	15	5	22·66	22	4	18·54	2	23	38·99
3.	2	28	13	15	5	31·69	22	4	27·54	2	23	47·99
4.	2	28	32	15	5	50·74	22	4	46·54	2	24	6·99
	2	28	34	15	5	52·74	22	4	48·54	2	24	8·99

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
5.	7	52	34	20	30	44·58	3	28	47·15	7	48	7·60
6.	8	11	35	20	49	48·64	3	47	48·09	8	7	8·54
	8	11	40	20	49	53·66	3	47	53·09	8	7	13·54

Whence the equations—

INGRESS.

$$\begin{array}{lrl}
1. & 5''{\cdot}319 = & 2{\cdot}454\,\delta\pi - \delta R - \delta\rho + 0{\cdot}507\,\delta\alpha + 0{\cdot}836\,\delta\Delta - 0{\cdot}052\,\delta t \\
2. & 1{\cdot}390 = & 2{\cdot}403\,\delta\pi - \delta R + \delta\rho + 0{\cdot}461\,\delta\alpha + 0{\cdot}866\,\delta\Delta - 0{\cdot}049\,\delta t \\
3. & 1{\cdot}835 = & 2{\cdot}403\,\delta\pi - \delta R + \delta\rho + 0{\cdot}461\,\delta\alpha + 0{\cdot}867\,\delta\Delta - 0{\cdot}049\,\delta t \\
4\ (\text{mean}). & 2{\cdot}828 = & 2{\cdot}402\,\delta\pi - \delta R + \delta\rho + 0{\cdot}460\,\delta\alpha + 0{\cdot}867\,\delta\Delta - 0{\cdot}049\,\delta t
\end{array}$$

EGRESS.

$$\begin{array}{lrl}
5. & 10''{\cdot}235 = & -2{\cdot}568\,\delta\pi + \delta R - \delta\rho + 0{\cdot}813\,\delta\alpha - 0{\cdot}474\,\delta\Delta - 0{\cdot}050\,\delta t \\
6. & \left\{\begin{array}{r} 4{\cdot}417 = \\ 4{\cdot}680 = \end{array}\right. & \begin{array}{l} -2{\cdot}592\,\delta\pi + \delta R + \delta\rho + 0{\cdot}835\,\delta\alpha - 0{\cdot}425\,\delta\Delta - 0{\cdot}053\,\delta t \\ -2{\cdot}592\,\delta\pi + \delta R + \delta\rho + 0{\cdot}835\,\delta\alpha - 0{\cdot}425\,\delta\Delta - 0{\cdot}053\,\delta t \end{array}
\end{array}$$

UNITED STATES.—CAMBRIDGE, MASS.

The observing station is only a very short distance from the Harvard College Observatory, and its position determined by direct measurements is—

	h.	m.	s.
Longitude - - - -	4	44	31·23 W. of Greenwich.
Latitude - - - - -	42°	22′	43″·3 N.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Messrs. J. R. Jewett and E. F. Sawyer.

Observed with a 4-inch refractor of 44 inches focal length, equatoreally mounted; power 150. The object-glass was smoked by the maker, Mr. Clacey, for direct vision, and worked admirably. The times given are Harvard College Observatory times.

INGRESS.

Mr. J. R. Jewett.

The morning of December 6 was very cloudy, and the prospect of success far from encouraging, but before the first contact the clouds began to break up, and, although not in time to observe the first contact, the second contact was quite well observed through a thin stratum of cirrus, this serving to dispel the formation of the "black drop" phenomenon.

At 21h. 39m. 45s., Harvard College mean time, second contact had taken place, this representing an apparent true geometrical contact. The interval between the morning and afternoon contacts was occupied in looking carefully over the whole disc of the Sun for a satellite, which it is needless to say was not observed, nor were any spots seen on the disc of the planet, or bright ring of light encircling the same.

EGRESS.

Mr. E. F. Sawyer.

The last contacts were observed under more favourable conditions than the morning contacts, notwithstanding a rather strong breeze blowing at the time, and the low altitude of the Sun. A slight haze, considered rather advantageous than otherwise, covered the sky in the south-west, and the Sun's limb appeared but slightly undulating. At 3h. 2m. 31·5s., H.C.M.T., the first "not yet" was recorded, the planet beginning to approach the Sun's limb, and this was repeated at intervals of a few seconds until 3h. 2m. 59·5s., when the word "past" was given. The moment of true contact was assumed to have taken place half-way between the last recorded "not yet" at 3h. 2m. 52s. and "past" at 3h. 2m. 59·5s., or at 3h. 2m. 56s., Harvard College mean time, and considered very good. The last contact was at 3h. 23m. 37s., Harvard College mean time. The moment of last contact was assumed to have occurred slightly more than half-way between the last recorded "not yet" at 3h. 23m. 24s., and the word "past" recorded at 3h. 23m. 47s. or at 3h. 23m. 37s. No black drop or ligament of any kind was observed, nor was Venus observed after leaving the Sun's disc.

Collecting the times, we have—

INGRESS.

	Local Sidereal Time.			Harvard College Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	14	40	48·98	21	39	45	2	24	15·98

EGRESS.

	Local Sidereal Time.			Harvard College Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
2.	20	4	53·07	3	2	56	7	47	26·98
3.	20	25	37·47	3	23	37	8	8	7·98

Whence the equations—

INGRESS.

$$1.\quad 1''\!\cdot\!324 = 2\cdot615\,\delta\pi - \delta R + \delta\rho + 0\cdot459\,\delta\alpha + 0\cdot868\,\delta\Delta - 0\cdot049\,\delta t$$

EGRESS.

$$2.\quad 6''\!\cdot\!761 = -2\cdot404\,\delta\pi + \delta R - \delta\rho + 0\cdot810\,\delta\alpha - 0\cdot480\,\delta\Delta - 0\cdot050\,\delta t$$
$$3.\quad 5\cdot887 = -2\cdot408\,\delta\pi + \delta R + \delta\rho + 0\cdot835\,\delta\alpha - 0\cdot427\,\delta\Delta - 0\cdot052\,\delta t$$

CANADA.—KINGSTON OBSERVATORY.

The longitude of the station from two exchanges of signals with the Toronto Observatory given in Mr. Carpmael's report is—

5h. 5m. 57·27s.† W. of Greenwich.

The latitude supplied by Professor Williamson is—

$44^\circ\ 13'\ 25''\!\cdot\!2$ N.

The above positions have only been used for the computation of the factors of parallax.

* Assuming Harvard College 4h. 44m. 30·98s. W. of Greenwich.
† Assuming Toronto Observatory 5h. 17m. 34·7s. W. of Greenwich.

Observations of the Contacts of the Sun and Venus.

Professor J. Williamson.

Observed with a 6¼-inch equatoreal by Alvan Clark and Sons, solar reflecting prism and neutral tint glass wedge, positive eye-piece power 120, which was found to give the sharpest and best defined vision of the limbs of the Sun and planet. The times of contacts were registered on a chronograph and also noted by chronometer Parkinson and Frodsham 2382, assisted by Professor Dupuis.

Ingress.

The weather for a week before the transit had been very unfavourable, and we began to fear that our preparations would prove fruitless after all, but we were agreeably disappointed by the 6th of December being, on the whole, a fine day, particularly so in the afternoon. The early morning sky was overcast, as the time for the commencement of the transit approached, however, it became clearer, and Professor Dupuis and I repaired to our posts, while Mr. James M. Dupuis was at hand to render very useful assistance in various ways as it might be necessary. One of the passing clouds which were beginning to disperse obscured the view of the first external contact, and the planet was in consequence not seen until it had partly entered on the Sun's disc. This was at 20h. 45m. 5s. by chronometer.

At 20h. 53m. by chronometer a line of light appeared round the planet on the side away from the Sun, and apparently brighter towards the southern limb of the planet.

The clouds had now passed away, and the approach to the first internal contact was noted at 21h. 1m. 25s. by chronometer, and by chronograph connected with mean time clock.

The first internal contact itself, that is, when the limbs of the Sun and planet appeared just to touch each other, took place, as nearly as could be judged, at 21h. 1m. 44s. by chronometer. For a little while after, the limbs seemed slightly to separate, a dark shade occupied the narrow interval between them, extending a little way on each side of the former points of apparent contact. The time when this dark shade began to break away and disappear occurred at 21h. 2m. 40s. by chronometer or 21h. 19m. 46·25s. by chronograph. This I regard as the true time of internal contact at ingress. There was still some remaining haziness in the atmosphere, but, as the sky was bright and free from clouds at the time, both of these contacts were very distinctly seen. There was nothing of the so-called black drop, but only the dark shade already referred to.

Egress.

Not long after the last contact at ingress clouds began again to spread over the sky, and continued to do so till about noon, when they again gradually passed off, and from 12h. 30m. p.m. to the end of the transit, as well as throughout the afternoon and evening, the heavens were perfectly clear. The first internal contact at egress took place at 2h. 42m. 53·20s. by chronograph. The dark haze seen at ingress in the morning began at this time to be again observed at egress, but the interval during which it continued and discontinuity was noted, was much shorter than in the forenoon, the last internal contact at egress, that is when the outlines of the limbs appeared exactly to touch, occurred at 2h. 43m. 12·54s. by chronograph. The former of these times I consider the true mean time by chronograph of internal contact at egress. The last external contact took place at 3h. 3m. 43·15s. by chronograph.

Collecting the times relating to the contacts, we have—

Ingress.

	h.	m.	s.		h.	m.	s.	
1. First internal contact	21	1	44*	by chronometer				
2. Disappearance of dark shade	21	2	40	„	21	19	46·25	by chronograph.

* No chronograph time given for this observation.

EGRESS.

	h.	m.	s.	
3. Appearance of dark haze - - - -	2	42	53·20	by chronograh.
4. Outlines of limbs appeared to touch - -	2	43	12·54	,,
5. Last external contact - - - -	3	3	43·15	,,

From the telegraphic signals exchanged between Kingston and Toronto Observatories, results of which are given in Mr. Carpmael's report of the Canadian observations of the Transit of Venus, 1882, we get the following corrections of the clock connected with the chronograph—

	h.	m.		m.	s.
December 5 at	11	37·7 by clock.	Clock fast of Toronto mean time	—12	20·74
,, 6 at	9	49·2 ,,	,, ,, ,,	—12	22·65.

We therefore get for times of contacts, assuming that first internal contact occurred exactly 56s. before disappearance of dark shade, as indicated by chronometer times.

INGRESS.

	Chronometer or Chronograph Time.			Local Sidereal Time.			Toronto Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	21	1	44	14	19	10·29	21	6	28·67	2	24	3·37
2.	21	19	46·25	14	20	6·45	21	7	24·67	2	24	59·37

EGRESS.

	Chronograph Time.			Local Sidereal Time.			Toronto Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
3.	2	42	53·20	19	44	6·02	2	30	31·16	7	48	5·86
4.	2	43	12·54	19	44	25·41	2	30	50·50	7	48	25·20
5.	3	3	43·15	20	4	59·36	2	51	21·08	8	8	55·78

Whence the equations—

INGRESS.

$$1.\quad 0''{\cdot}211 = 2{\cdot}672\ \delta\pi - \delta R + \delta\rho + 0{\cdot}460\ \delta\alpha + 0{\cdot}867\ \delta\Delta - 0{\cdot}049\ \delta t$$
$$2.\quad 2{\cdot}949 = 2{\cdot}671\ \delta\pi - \delta R + \delta\rho + 0{\cdot}458\ \delta\alpha + 0{\cdot}868\ \delta\Delta - 0{\cdot}049\ \delta t$$

EGRESS.

$$3.\quad 7''{\cdot}739 = -2{\cdot}295\ \delta\pi + \delta R - \delta\rho + 0{\cdot}810\ \delta\alpha - 0{\cdot}480\ \delta\Delta - 0{\cdot}050\ \delta t$$
$$4.\quad 8{\cdot}687 = -2{\cdot}295\ \delta\pi + \delta R - \delta\rho + 0{\cdot}810\ \delta\alpha - 0{\cdot}479\ \delta\Delta - 0{\cdot}050\ \delta t$$
$$5.\quad 7{\cdot}415 = -2{\cdot}301\ \delta\pi + \delta R + \delta\rho + 0{\cdot}835\ \delta\alpha - 0{\cdot}426\ \delta\Delta - 0{\cdot}052\ \delta t.$$

CANADA.—OTTAWA.

The temporary observatory was erected on Nepean Point.

The longitude of the station from two exchanges of signals with the Toronto Observatory extracted from Mr. Carpmael's report is—

	h.	m.	s.
Ottawa (Nepean Point) east of Toronto Observatory - -	0	14	47·2
Toronto Observatory west of Greenwich - - - -	5	17	34·7
or—			
Ottawa (Nepean Point) west of Greenwich - - -	5	2	47·5

The approximate latitude is—

45° 26′ N.

ͻnly been used for the computation of the parallax

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tory supplied by Mr. Carpmael is 5h. 17m. 34·7s. W. of Greenwich.

Observations of the Contacts of the Sun and Venus.

Mr. F. L. Blake.

Observed with a 4-inch achromatic telescope, altazimuth mounting. The definition of the telescope is noted as very fine, no information of power used is given. Times noted by Mr. B. C. Webber with chronometer Frodsham 1752.

Ingress.

The morning of the 6th broke with dense clouds at low elevation with no immediate prospect of breaking. Soon after eight o'clock signs of clouds dispersing in S.E. At 8h. 15m. by chronometer Sun shone out brilliantly. Sighted on the Sun and focussed on Sun spots, at 8h. 24m. rice grains on Sun just discernible.

At first external contact atmosphere rather hazy. Time of first external contact 8h. 34m. 45s. by chronometer. This time is not to be depended on as my attention was called away just at moment of contact and had to estimate, the notch being formed on the Sun when I again put my eye to the telescope. I do not think it can be more than five or six seconds out at most.

At no time could I detect any portion of the planet that was off the Sun. The portion on the Sun was very black. Towards internal contact clouds began to pass over the Sun, hiding it completely at times. Just before internal contact caught a glimpse of the Sun through a break in the clouds which lasted long enough to catch the contact. No black drop observed. Bright cusps of the Sun met at 8h. 54m. 51s. by chronometer. The Sun became obscured at 8h. 55m. 8s. by chronometer, during which interval of 17 seconds the band of light between the limbs of Venus and the Sun broadened considerably. The time 8h. 54m. 51s. was the last time of appearance of discontinuity in the illumination of the apparent limb of the Sun. Sun reappeared at 9h. 11m. with prospects of a fine afternoon. For an hour, with the exception of the time occupied in the passage of a few fleecy clouds over the Sun, the planet was observed. No markings of any kind could be distinguished on its surface which appeared intensely black in comparison with the bright face of the Sun. Clouds again gathered thickly, and snow began to fall.

Egress.

Snowstorm continued without intermission up till 2h. 5m., when clouds began to clear off in the south-west, and the Sun began to peep out, when Venus was observed approaching internal contact at egress, being then about half its own diameter from limb of Sun. Mr. Webber began to count at 2h. 16m. At 2h. 17m. 19s. by chronometer, slight fading was observed near point of contact which gradually increased until 2h. 18m. 0s. by chronometer, when contact was observed by first appearance of blackness like that of the planet, and the bright cusps began to recede.

No black drop or distortion of the limb of Venus was observed although the edge of the Sun was boiling just a little.

I used an illumination about midway between total darkness and brightness that the eye could just bear.

When the planet was half way off the Sun, I thought I could faintly discern the limb off the Sun, but could not be sure of it. Between internal and external contacts nothing unusual was observed. At 2h. 38m. 12s. by chronometer the dark body of the planet left the Sun, although a faint shading of the limb of the Sun near point of contact till 2h. 38m. 31s. was observed; nothing unusual in the illumination of the limb of the Sun was observed after that time. For about an hour after external contact at egress the Sun shone brilliantly, when clouds again arose, and the Sun was shrouded from sight for the rest of the day.

Collecting the times relating to the contacts, we have—

Ingress.

	h.	m.	s.	
1. First external contact - - - -	20	34	45	by chronometer.
2. Last appearance of discontinuity, &c. -	20	54	51	„

EGRESS.

		h.	m.	s.	
3.	Slight fading near point of contact	2	17	19	by chronometer.
4.	Contact	2	18	0	,,
5.	Dark body of Venus left the Sun	2	38	12	,,
6.	Faint shading of Sun's limb till	2	38	31	,,

We therefore get for times of contacts—

INGRESS.

	Chronometer Time.			Local Sidereal Time.			Toronto Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	20	34	45	14	2	59·60	20	47	11·37	2	4	46·07
2.	20	54	41	14	23	8·96	21	7	17·43	2	24	52·13

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Toronto Mean Time.			Greenwich Mean Time.*		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
3.	2	17	19	19	46	30·90	2	29	46·40	7	47	21·10
4.	2	18	0	19	47	12·03	2	30	27·41	7	48	2·11
5.	2	38	12	20	7	27·40	2	50	39·46	8	8	14·16
6.	2	38	31	20	7	46·46	2	50	58·47	8	8	33·17

Whence the equations—

INGRESS.

$$1.\quad 5''\!\cdot\!747 = 2\cdot697\,\delta\pi - \delta R - \delta\rho + 0\cdot504\,\delta\alpha + 0\cdot837\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 2\cdot557 = 2\cdot675\,\delta\pi - \delta R + \delta\rho + 0\cdot458\,\delta\alpha + 0\cdot868\,\delta\Delta - 0\cdot049\,\delta t$$

EGRESS.

$$3.\quad 5''\!\cdot\!533 = -2\cdot297\,\delta\pi + \delta R - \delta\rho + 0\cdot809\,\delta\alpha - 0\cdot482\,\delta\Delta - 0\cdot050\,\delta t$$
$$4.\quad 7\cdot556 = -2\cdot297\,\delta\pi + \delta R - \delta\rho + 0\cdot810\,\delta\alpha - 0\cdot480\,\delta\Delta - 0\cdot050\,\delta t$$
$$5.\quad 5\cdot226 = -2\cdot297\,\delta\pi + \delta R + \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot428\,\delta\Delta - 0\cdot052\,\delta t$$
$$6.\quad 6\cdot226 = -2\cdot297\,\delta\pi + \delta R + \delta\rho + 0\cdot835\,\delta\alpha - 0\cdot427\,\delta\Delta - 0\cdot052\,\delta t$$

CANADA.—COBOURG.

The approximate position of the observing station taken from United States charts of Lake Ontario is—

	h.	m.	s.	
Longitude	5	12	37·5	W. of Greenwich.
Latitude	43°	57′		N.

These positions have only been used for the computation of the parallax factors.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Professor A. R. Bain.

Observed with a 4½-inch refractor by Smith, Beck and Beck, London; equatoreally mounted; power about 150. Mr. Bain was assisted by Drs. Haanel and Coleman, the latter gentleman took the times from the chronometer.

EGRESS.

he sky in the early part of the morning of December 6 was clear enough to justify most sanguine expectations of getting good observations of at least the first tacts, but a few minutes before 8 a.m., dense masses of cloud began to rise in the

* The longitude of the Toronto Observatory supplied by Mr. Carpmael is 5h. 17m. 34·7s. W. of Greenwich.

north-west, and by 10 minutes past 8 the whole heavens, with the exception of a small area in the north-east and east, were covered, competely shutting out the Sun from view. These clouds did not break away until long after external and internal contact at ingress had passed.

About 10h. 30m. a.m. rifts in the clouds appeared, and shortly before 11 a clear view of the planet on the Sun's disc was obtained. The disc of the planet, especially towards its circumference, presented a purplish hue, while the centre had a faint light spot slightly tinged with a pale slaty green.

Shortly before 2 the atmosphere which had been comparatively steady began to be disturbed, and rapidly became worse, while flying clouds now and again swept across the face of the Sun. Before the time of internal contact at egress, the boiling of the atmosphere was such as to render observations very unsatisfactory.

The limbs of the Sun and planet appeared to spin. The limb of the Sun at which contact was about to take place seemed to consist of filaments of light, each revolving swiftly in a small spiral.

Internal contact at egress appeared to take place at 2h. 33m. 27s. by chronometer. Just at this critical moment a cloud swept Sun and planet out of sight, and when it had passed a small arc of the planet's limb was decidedly beyond the Sun's limb, while a narrow beautifully distinct white line of light surrounded that portion of the planet's limb which was beyond the Sun. When about half the planet's disc had crossed the Sun's limb, the line of light was decidedly broader on the north-western portion than it was along the remaining arc. Very soon after clouds hid the Sun from sight and prevented any observation being taken of the external contact at egress.

Professor Bain further says in a letter dated 1883, January 25—

"I have the honour to acknowledge the receipt of your note of January 20th, in which you ask for a further description of phenomena seen at the instant of time at which I had marked down the words 'Ap. Contact.'"

In the report already sent I refer to the atmospheric disturbance which grew worse and worse till all vision of Sun and planet was lost under the flying clouds.

The ever narrowing band of light over which the planet was slowly moving as it approached the Sun's limb was heaving, boiling, and apparently spinning in a manner described in previous report, other than this, nothing peculiar was seen. No black drop presented itself. No distortion of the planet's limb such as an elongation towards point of contact, nor till after part of the planet was beyond the Sun's disc did any arc of white light surround any part of the planet's disc. The exact instant when that beautiful bright white arc of light first appeared I know not, for just after what seemed to be contact a cloud came over, and when it was passed the arc of light was there. The cloud was on the face of planet and Sun fully five seconds.

It was impossible to take a point north and another south of the point at which contact was about to take place, and note when the illumination of the point of contact began to be distinctly less than that of the points chosen, for the Sun's limb was not still enough to admit of any such thing. It appeared constantly to heave and surge.

With this exception the planet moved steadily towards contact, presenting no phenomena different from those observed at any earlier stage. The various times correspond simply to remarks made at the telescope, while the observation was making, the exact words used, and the instant at which each phase was spoken, being noted by the assistants.

This plan was adopted thinking that if any marked phenomenon presented itself near time of contact, before or after, the exact second of time when observed could thus be noted, but nothing in addition to the phenomena already described was seen.

In giving you the colours of the disc of planet I described exactly as seen in our telescope, of course the purplish hue of the edge would at once inform you that our glasses are somewhat over corrected.

I forget to mention that during the day the Sun's surface was mottled, but presented no well marked rice grains, no interlacing willow pattern.

Again Professor Bain says on February 21st, 1883—

"Dr. Coleman put 'ap.' down in the hurry, but 'approaching' was the word used."

The times given for the preceding notes are—

	h.	m.	s.	
Atmosphere very unsteady - -	2	32	44	by chronometer.
Approaching contact - - -	2	33	5	"
Now - - - - -	2	33	27	"
Cloud - - - - -	2	33	33	"
Passed - - - - -	2	33	38	"

The time given for contact in Professor Bain's report is—

h.	m.	s.	
2	33	27	by chronometer,

corresponding to the "Now" given above.

The chronometer correction at time of contact given by Mr. Carpmael is—

Chronometer *fast* of Toronto mean time - - - 2m. 28s.53

We therefore get for time of contact—

Chronometer Time.			Local Sidereal Time.			Toronto Mean Time.			Greenwich Mean Time.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
2	33	27	19	37	53·18	2	30	58·47	7	48	33·17

Whence the equation—

$$8''\!\cdot\!833 = -\ 2{\cdot}264\ \delta\pi + \delta R - \delta\rho + 0{\cdot}811\ \delta\alpha - 0{\cdot}479\ \delta\Delta - 0{\cdot}050\ \delta t$$

CANADA.—WINNIPEG.

Longitude of station - - 6h. 28m. 29s.67 W. of Greenwich.

Latitude „ - - 49° 55′ N.

Observations of the Contacts of the Sun and Venus.

Professor C. H. McLeod.

Observed with a 4-inch refracting altazimuth telescope, a first surface reflecting prism, a neutral tint wedge, and an Airy eye-piece; power 160. Prof. McLeod remarks that the mounting of the instrument was very steady. The disc of a bright star out of focus is round, but with a somewhat jaggy edge. There is the usual change of colours as the eye-piece is pulled out, viz., from greenish to a green centre bordered with purple, and beyond the focus a purple centre bordered by green, changing, as it is pulled still further out, to a uniformly light purple disc. On a night of not very good definition and full moonlight, σ Cassiopeiæ was easily seen double. The "rice grains" on the day of the transit were just visible with the thin end of the wedge. The rice grains are generally easily visible. The times were noted by chronometer Murray 652 by Mr. Payne.

Egress.

On the morning of December 6, the Sun was obscured by cloud and snow drift until after 9 o'clock. When the Sun had risen above the cloud and snow banks it remained visible until it had again sunk behind them in the afternoon. The temperature was 18° below zero (Fah.), and the velocity of the wind was 24 miles per hour.

On reaching the station shortly before 11 a.m., and directing the telescope on the Sun, it was found to shake so violently as to make it impossible to keep the Sun in view. We immediately set to work to screen the telescope from the wind. After moving it back so that it stood entirely within the shelter, we covered the roof opening with the exception of a hole about 1 foot square, through which the Sun could be seen for some time before and after the contacts at egress. The telescope was then found to be perfectly steady. All arrangements were completed, and the telescope directed on the Sun shortly before 1 o'clock, from which time until after the third contact Venus was kept in view, principally by Mr. Payne, as I wished to rest my eyes as much as possible before making the observations.

Shortly after 1h. 19m. p.m., Mr. Payne began counting seconds. The following is an exact copy of the record—

	h.	m.	s.	
Light about to be broken - - -	1	21	55	by chronometer.
Blackness all the way across a second or two before this - - -	1	22	11	„
Last appearance of gap, approximate -	1	42	13	„

Rice grains just visible at internal contact. Illumination poor. Extreme thin end of wedge used, giving too dark a field, but Sun very much too bright to be observed without the wedge. This applies more particularly to the last contact; at times near the internal contact the illumination was nearly as bright as I desired; but, considering the observation as a whole, the field was too dark. I should say the time of actual internal contact,—"the first appearance of any well-marked and persistent discontinuity in the illumination of the Sun near the point of contact,"—was considerably nearer the first time 1h. 21m. 55s. than the second time 1h. 22m. 11s. The time I would wish to be taken as the moment of contact as above defined is 1h. 22m. 0s. by chronometer.

At 1h. 42m. 13s. (by chronometer) there was the slightest possible appearance of a gap in the limb of the Sun. Just then the illumination became very bad, and my eye being rather tired, I lost sight of the point of contact.

I have preferred to give my notes as made during the progress of the observations, and immediately after it, rather than what might, perhaps, better express my meaning, written at this time. I desire, however, to make the following addition to these notes.

Definition was fairly good, there being little or no boiling of the Sun's limb. My remarks as to illumination were written immediately after the last contact, and were made with the then conditions of the atmosphere in my mind, and were undoubtedly intended to refer to that time only. These remarks are, however, correctly qualified in what follows them. The important point is that at internal contact the seeing was sufficiently good to leave no doubt whatever as to what I saw. There was no "black drop," but merely a haze, which gradually increased to complete blackness. There was no haze at 1h. 21m. 55s. by chronometer, but it was the last instant at which I could definitely say there was no appearance of haze. I waited rather too long before giving the second signal at 1h. 22m. 11s., and for this reason made the note attached thereto. The time I have indicated as what I would desire to be taken as the time of internal contact must be very near the truth.

I stopped observing at 1h. 24m., and did not recommence until 1h. 39m.

The word "approximate" following the remark opposite to 1h. 42m. 13s. does not express what was intended. At that time the gap *was* seen, but it was not seen afterwards. Had I continued to see it I do not think that any appearance of "gap" would have been visible for more than five seconds after the recorded time.

After both internal and external contacts, I verified Mr. Payne's counting by looking at the chronometer and his record.

Collecting the times, we have—

	h.	m.	s.	
1. Internal contact - - -	1	22	0	by chronometer.
2. Last appearance of gap -	1	42	13	„

We therefore have—

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	1	22	0	18	22	56·88	1	20	59·23	7	49	28·9[illegible]
2.	1	42	13	18	43	13·24	1	41	12·27	8	9	41·94

Whence the equations:—

$$1.\quad 7''{\cdot}679 = -1{\cdot}823\,\delta\pi + \delta R - \delta\rho + 0{\cdot}810\,\delta\alpha - 0{\cdot}480\,\delta\Delta - 0{\cdot}052\,\delta t$$

$$2.\quad 5{\cdot}631 = -1{\cdot}826\,\delta\pi + \delta R + \delta\rho + 0{\cdot}834\,\delta\alpha - 0{\cdot}428\,\delta\Delta - 0{\cdot}053\,\delta t$$

NEW ZEALAND.—BIDWILL'S.

		h.	m.	s.	
Longitude of the station	-	11	41	41·47	E. of Greenwich.
Latitude ,, ,,	-	41°	11′	29″	S.

Observations of the Contacts of the Sun and Venus.

Mr. J. H. A. Marchant.

Observed with a 4-inch refractor by Browning, kindly lent by Mr. David Gray, of Wellington; focal length, 5 feet 6 inches; power about 200; first surface reflecting prism and neutral tint glass wedge. The motion in altitude and azimuth is effected by hand rods and slow motion screws. Seconds of chronometer Barraud 2432 called aloud by Mr. G. Struthers. Mr. Wright supervised the calling, booked each minute, and noted down times and remarks.

Egress.

	h.	m.	s.	
1. Suspicion of haze	12	41	57	by chronometer.
2. Haze undoubtedly	12	42	14	,,
3. Contact without doubt	12	42	25	,,

The limb of Sun was sharply defined; limb of Venus not so well, as she appeared to be surrounded by a haze. No "boiling" appearance about Sun's rim.

The time, 12h. 42m. 14s., was the instant at which the "haze" was unmistakably visible between the limbs of Venus and the Sun; and the time, 12h. 42m 25s., was the instant at which the "haze" became black in the centre near the points of contact.

Shortly afterwards the rim of the Sun appeared to advance before the outward limb of Venus, that is to say, it appeared to be pushed out by the black disc of the planet, and the aureole was distinctly visible round the outward rim of Venus.

	h.	m.	s.	
4. Cessation of indentation of Sun's limb outward, contact at egress -	13	1	50	by chronometer.

After this time no trace of the planet was to be seen.

Definition good. Sun spots and mottled appearance of surface were seen very distinctly before and after egress; in fact, the definition was exceptionally good.

Collecting the times, we have—

Egress.

	Chronometer Time.			Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	12	41	57	12	44	45·06	19	40	9·94	8	1	4·03
2.	12	42	14	12	45	2·05	19	40	26·88	8	1	20·97
3.	12	42	25	12	45	13·05	19	40	37·85	8	1	31·94
4.	13	1	50	13	4	38·02	19	59	59·64	8	20	53·73

Whence the equations—

$$
\begin{array}{ll}
1. & 7{\cdot}078 = 2{\cdot}214\,\delta\pi + \delta R - \delta\rho + 0{\cdot}833\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}053\,\delta t \\
2. & 7{\cdot}964 = 2{\cdot}212\,\delta\pi + \delta R - \delta\rho + 0{\cdot}833\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}053\,\delta t \\
3. & 8{\cdot}535 = 2{\cdot}211\,\delta\pi + \delta R - \delta\rho + 0{\cdot}833\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}053\,\delta t \\
4. & 6{\cdot}645 = 2{\cdot}083\,\delta\pi + \delta R + \delta\rho + 0{\cdot}853\,\delta\alpha - 0{\cdot}383\,\delta\Delta - 0{\cdot}055\,\delta t
\end{array}
$$

Observations of the Contacts of the Sun and Venus.

Captain J. D. Hewitt.

Observed with an $8\frac{1}{2}$-inch Browning reflector.

Egress.—External Contact.

From the "Report on the Surveys of New Zealand, 1882–83," the time of external contact is given at 13h. 1m. 54s., Mount Cook sidereal time. No further information has been received. This gives—

Egress.—External Contact.

	Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	13	4	29·56	19	59	51·20	8	20	45·29

Whence the equation—

$$1.\quad 6''\!\cdot\!174 = 2\cdot083\,\delta\pi + \delta R + \delta\rho + 0\cdot853\,\delta\alpha - 0\cdot383\,\delta\Delta - 0\cdot055\,\delta t$$

NEW ZEALAND.—MOUNT COOK OBSERVATORY, WELLINGTON.

The longitude of the observatory, obtained by exchange of telegraphic signals with the Sydney Observatory, is—

	h.	m.	s.
Mount Cook Observatory east of Sydney Observatory - - - - -	1	34	16·98
Sydney Observatory east of Greenwich -	10	4	48·93

Therefore—

	h.	m.	s.
Mount Cook Observatory east of Greenwich -	11	39	5·91

The latitude is—

$$41^\circ\ 18'\ 0''\!\cdot\!6\ \text{S.}$$

Observations of the Contacts of the Sun and Venus.

Mr. C. W. Adams.

Observed with $4\frac{1}{8}$-inch telescope by S. and B. Solomons, of 5-feet focal length, kindly lent by Mr. H. Barnard, of Taranaki Street, Wellington. It was mounted on an ordinary stand, and required to be moved by hand; power 71, the highest power available, was used. No first surface reflecting prism could be obtained in time, nor a graduated glass wedge, so the image of the Sun was thrown on a screen. The screen was 21·9 inches from the eye-piece, and the Sun's image was larger than the field of view; but if the whole of the Sun's image could have been seen at once, it would have been 14·8 inches in diameter. The telescope was set up just outside the observatory door. The times were noted by the sidereal clock, Mr. W. Holmes counting seconds in an audible voice, and Mrs. Adams noted down the times and remarks.

Egress.

About 6 a.m. the edges of the discs of Venus and the Sun appeared very tremulous and "boiling," but as the time of contact approached the definition became much more sharp and distinct.

I have very little to record besides the times of actual contact, as there was an almost entire absence of the incidental phenomena that I had been led to expect.

I kept watching for the hazy or cloudy appearance which I expected would present itself before internal contact, and fancied I saw a very slight darkening at the edge of the Sun's limb at 12h. 41m. 50s. by clock. The internal contact I noted at 12h. 42m. 10s. by clock; it was a pure geometrical contact, neither blur nor distortion being visible.

I noticed no other phenomena between internal and external contact.

External contact I noted at 13h. 2m. 6s. by clock.

The opinion I formed immediately after the transit was that the error of my observations could not exceed a limit of two or three seconds at internal and five or six seconds at external contact.

The sky was beautifully clear and the weather calm.

Collecting the times given, we have—

	h.	m.	s.	
1. Suspicion of slight darkening - -	12	41	50	by clock.
2. Internal contact - - - -	12	42	10	„
3. External contact - - -	13	2	6	„

We therefore get—

EGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	12	42	1·57	19	40	2·03	8	0	56·12
2.	12	42	21·57	19	40	21·98	8	1	16·07
3.	13	2	17·53	20	0	14·67	8	21	8·76

Whence the equations :—

$$
\begin{array}{lrcl}
1. & 6''{\cdot}560 & = & 2{\cdot}225\ \delta\pi + \delta R - \delta\rho + 0{\cdot}833\ \delta\alpha - 0{\cdot}430\ \delta\Delta - 0{\cdot}052\ \delta t \\
2. & 7{\cdot}603 & = & 2{\cdot}225\ \delta\pi + \delta R - \delta\rho + 0{\cdot}833\ \delta\alpha - 0{\cdot}430\ \delta\Delta - 0{\cdot}052\ \delta t \\
3. & 7{\cdot}353 & = & 2{\cdot}095\ \delta\pi + \delta R + \delta\rho + 0{\cdot}853\ \delta\alpha - 0{\cdot}382\ \delta\Delta - 0{\cdot}055\ \delta t
\end{array}
$$

These observations have not been included in the final equation, as the method of observation was entirely different from the rest.

NEW ZEALAND.—BOULCOTT STREET, WELLINGTON.

The longitude of the station is given as 0·34s. W. of Mount Cook Observatory; it is therefore—

h. m. s.
11 39 5·57 E. of Greenwich.

The latitude supplied by the Surveyor-General of New Zealand is—

$41^\circ\ 17'\ 14''{\cdot}3$ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. J. McKerrow.

Observed with a 5-inch Grubb equatoreal belonging to Mr. King, who kindly lent it and the use of his observatory for the transit; power used, 250. Neutral tint, dark glass, and a first surface reflecting prism. A compensated neutral-tint wedge was available, but Mr. McKerrow preferred the dark glass, as through it there was no unsteadiness whatever. With the object of diminishing any tremor which might arise from the reflection of the Sun's rays from the dome and walls of the observatory, these were painted, a few days prior to the observation, with paint of a neutral tint, and during the observation were covered with white calico. The times were noted by sidereal clock. Messrs. Alexander Barron and Thomas Grant, officers of the Survey Department, assisted in the taking of time and the record of observations.

Egress.

The observation of the Transit of Venus at Mr. King's Observatory, Boulcott Street, by me was most satisfactory, inasmuch as there was no boiling or tremor of the Sun's limb, nor was there any rim of light or other phenomena around the limb of Venus. The limbs of both Sun and planet were sharp and distinct, and as they approached each other the instant when the Sun's limb was disturbed, and rendered obscure by a rapidly thickening haze or mistiness, was also very well marked, and was noted to the nearest second. The geometrical contact of the two limbs, that is to say, when the two appeared to touch each other, was very distinct, there being no drop or pear-shaped appearance of the planet. With these two phases the observation was completed; but, as a rough check on these observations, a third time was noted when the two limbs had overlapped, forming a ligature or band, which in reality was the distance between the cusps of Venus as figured on the limb of the Sun.

The time of external contact was not marked by any phenomena other than the gradual approach of the cusps of Venus as the planet retired from the Sun. Although the circumstances of this observation as to steadiness and definition were most favourable, the time noted is probably uncertain to two seconds, but not more. In conclusion I have to add that in the absence of clouds, wind, or other disturbing cause of weather, I cannot conceive of more favourable conditions for the observation.

The times are—

	h.	m.	s.	
1. Disturbance of Sun's limb by dark haze -	12	42	3	by clock.
2. Contact complete, the two limbs being geometrically united - - -	12	42	12	,,
3. Ligature formed by limbs overlapping -	12	42	18	,,
4. Cusps met, Venus off the Sun - -	13	2	6	,,

We therefore get—

Egress.

	Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	12	42	13·02	19	40	13·79	8	1	7·88
2.	12	42	22·02	19	40	22·76	8	1	16·85
3.	12	42	28·02	19	40	28·75	8	1	22·84
4.	13	2	15·92	20	0	13·40	8	21	7·49

Whence the equations—

$$1.\quad 7''\!\cdot\!169 = 2\cdot225\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 7\cdot646 = 2\cdot225\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t$$
$$3.\quad 7\cdot965 = 2\cdot225\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t$$
$$4.\quad 7\cdot282 = 2\cdot095\,\delta\pi + \delta R + \delta\rho + 0\cdot853\,\delta\alpha - 0\cdot382\,\delta\Delta - 0\cdot055\,\delta t$$

NEW ZEALAND.—CHRISTCHURCH.

	h.	m.	s.	
Longitude of the station - -	11	30	30·94	E. of Greenwich.
Latitude ,, ,, - -	43°	31′	40″	S.

Observations of the Contacts of the Sun and Venus.

Mr. W. Kitson.

Observed with a 6-inch Cooke equatoreal, kindly lent by Mr. J. Townsend, together with the use of his observatory; power used, 173. First surface reflecting prism and compensated neutral-tint glass wedge placed between the eye and eye-lens.

EGRESS.

During the whole of the observation a light slightly-streaky cirrus cloud was apparent over the whole of the sky.

At about 6.55 a.m., when the planet was observed, no halo nor any light at all different from the light of the Sun was visible round the planet, nor was there any shadow round the planet's limb. The face of the Sun presented a disc of one uniform and continuous light, the only dark spot being the planet itself.

The planet itself appeared to have a lighter tinge towards its limb. This light tinge began to displace the blackness of the centre at about one-tenth of the planet's diameter from the edge. This tinge was of a bluish colour, the centre being almost black.

From this spot the light tinge extended outwards continuously to the edge of the planet. I could not detect the appearance of rice grains on the face of the Sun at any time.*

The first time, 7h. 31m. 2·5s., corresponds to the first appearance to me of a shadow or darkening of the Sun's face between the limbs of the planet and Sun near the point of contact.

There was no black drop as I understood black drop, *i.e.*, no absolute apparent meeting of the two limbs, nor was there any thrusting out of the Sun's limb by the planet, as I understood was probable.

The second phenomenon, 7h. 31m. 24·5s., occurred when the light between the planet and the Sun's limb was distinctly obscured, the phenomenon differing from a haze.

This moment was also estimated mentally by the production of the two limbs of the Sun and planet, where they were unaffected to the point of contact. I estimated this time to be the geometric contact. During the last few seconds of observation the whole effect was rather hazy, probably owing to a cloud intervening.

After first contact at egress the portion of the planet off the Sun was wholly invisible to me.

Phenomenon corresponding to time 7h. 50m. 53·5s. During the final contact or separation of the limbs the definition was excellent, much more perfect than at first contact.

Collecting the times—

	h.	m.	s.	
1. First shadow - - -	7	31	2·5	by chronometer.
2. Internal contact - - -	7	31	24·5	,,
3. Final separation - - -	7	50	53·5	,,

We have therefore—

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Burnham Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	7	31	2·5	12	33	30·70	19	30	13·09	8	1	0·21
2.	7	31	24·5	12	33	52·76	19	30	35·09	8	1	22·21
3.	7	50	53·5	12	53	24·89	19	50	4·02	8	20	51·14

Whence the equations—

$$1.\quad 6''{\cdot}589 = 2{\cdot}248\,\delta\pi + \delta R - \delta\rho + 0{\cdot}833\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}052\,\delta t$$
$$2.\quad 7{\cdot}741 = 2{\cdot}245\,\delta\pi + \delta R - \delta\rho + 0{\cdot}834\,\delta\alpha - 0{\cdot}429\,\delta\Delta - 0{\cdot}052\,\delta t$$
$$3.\quad 6{\cdot}173 = 2{\cdot}120\,\delta\pi + \delta R + \delta\rho + 0{\cdot}853\,\delta\alpha - 0{\cdot}382\,\delta\Delta - 0{\cdot}055\,\delta t$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. J. Townsend.

Observed with a $3\frac{3}{8}$-inch Dallmeyer equatoreal.

Times taken by a watch showing seconds, which was compared with the chronometer used by Mr. Kitson shortly before and immediately after the transit.

* Colonel Tupman remarks :—" Mr. Kitson tells me that he cannot see the solar granulations with any " instrument, and it was certainly through no defect of the instrument that he was unable to see them. I " frequently turned it on the Sun and also on stars, and found its defining powers excellent. The compensated " wedge fitted to the eye-piece was brought from England as a spare one for the Pembroke equatoreal. Every- " thing connected with the instrument was Cooke's best work."

EGRESS.

Saw Venus on Sun's disc shortly after sunrise. Light cirrus clouds hanging about, but generally bright and fine weather.

		h.	m.	s.	
1.	First shadow at contact - -	19	31	13	by chronometer.
2.	Contact complete - - -	19	31	28	,,
3.	Venus left Sun's limb (at 10s. not seen) - - - -	19	51	9	,,

Part of outline of Venus seen till 12 minutes after internal contact, outside limb of Sun. Centre of planet when on the Sun quite black, margin for one-third diameter indigo. At last moment of internal contact light line on advancing limb of planet, which became very obvious on separation from Sun. No markings or light seen on body of Venus.

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Burnham Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	19	31	13	12	33	46·04	19	30	28·39	8	1	15·51
2.	19	31	28	12	34	1·08	19	30	43·39	8	1	30·51
3.	19	51	9	12	53	45·24	19	50	24·32	8	21	11·44

Whence the equations—

$$1.\quad 7''\!\cdot\!387 = 2\cdot246\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot429\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\quad 8\cdot165 = 2\cdot244\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot429\,\delta\Delta - 0\cdot052\,\delta t$$
$$3.\quad 7\cdot288 = 2\cdot117\,\delta\pi + \delta R + \delta\rho + 0\cdot853\,\delta\alpha - 0\cdot381\,\delta\Delta - 0\cdot055\,\delta t$$

NEW ZEALAND.—BURNHAM.

	h.	m.	s.	
Longitude of station - -	11	29	12·88	E. of Greenwich.
Latitude ,, - - -	43°	36′	48″·1	S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Lieut.-Col. Tupman.

Observed with a 6⅛-inch Cooke equatoreal; power 210. A first surface reflecting Herschelian prism, a compensated wedge of neutral tint inclining to blue, being attached to the eye-piece between the eye-lens and the eye. Chronometer F. was used for times.

EGRESS.

The early morning of December 7 was fine with but little cloud, and scarcely a breath of wind. I had the roofs and eastern sides of the telescope huts entirely removed, so that the telescopes were practically in the open air, a great advantage, especially for solar observations.

By 6 o'clock all was in readiness, and everyone at his post. Every part of both telescopes was clean and in good order, and the driving clocks ran true. I was assisted by my wife, who counted aloud the seconds from the chronometer, and by Mr. Gill, of the Telegraph Department, Wellington, who wrote for me, and called each minute. The chronometer was so placed that I could see its face. Bombardier Wilson also assisted in the hut.

At 18h. 25m. Burnham Mean Time, December 6, I examined the Sun with a power of 150, an ordinary negative eye-piece, fitted as described. The planet was as black as ink, the outstanding blue of the object glass conspicuous along the limb on the black

disc. The granulations of the Sun's surface were remarkably distinct; there was scarcely any boiling, and no cloud over the Sun.

Carefully examining the edge of the planet, I could distinguish no trace of her atmosphere. The limb was absolutely sharp, of striking abruptness. There was no trace of any shadow on the Sun's surface without the planet, or of any light within the planet's disc. I assured myself of this repeatedly during the hour or more that I had little else to do. The granulations of the Sun's surface, the "rice grains" and the tiny "pores" were everywhere visible close up to the limb of Venus. She passed over a more disturbed portion of the photosphere when the solar markings were seen in actual contact with the limb of the planet.

At 18h. 37m. I inserted the Airy double-image micrometer, which was nicely adjusted, and took measures of the double diameter of Venus.

At 18h. 50m. I tried power 210 with good effect. There was so little disturbance of the air that a still higher power might have been employed. The solar granulations were still seen close up to the limb of the planet.

Venus being about her own diameter from the Sun's limb, I replaced the micrometer, and made measures of the distance of near limbs.

A white hazy cloud had for some time been spreading over the Sun depriving the planet's disc of the inky blackness before noticed, but there was scarcely any boiling.

At 19h. 25m. haze over the Sun, vision becoming indistinct.

At 19h. 28m. I no longer saw the granulations. Image steady; very little boiling. Venus' disc very sharply defined.

At 19h. 28m. 30s. my wife began to count aloud the seconds. Venus drew pretty quickly up to the Sun's limb. I expected to see the shadow between the limbs sooner than I actually did. The distance became very small without any diminution of the Sun's light, certainly to within one second of arc. A faint shadow grew slowly between the limbs. At 19h. 30m. 7s. by chronometer I began to suspect it; at 19h. 30m. 11s. I was sure of it. A short ill-defined shadow, not many seconds long, in the direction parallel to the limbs; undoubtedly difficult to see, which might have been due to the haze over the Sun.

At 19h. 30m. 20s. by chronometer the Sun's limb had lost its sharpness from the overlapping of Venus' atmosphere, and at 19h. 30m. 27s. the atmosphere was conspicuous, connecting the now formed cusps. All the phenomena relating to internal contact were now passed. I found it too difficult to estimate the instant of "geometric" contact.

The recorded time, 19h. 30m. 11s. by chronometer, when I was first sure of the existence of the shadow, is the time I consider to apply best to the definition of contact in the "instructions." I verified the minute. I can state positively that there was no diminution of the Sun's light, or disturbance of the limb prior to 19h. 30m. 7s. by chronometer. The illumination in the planet's atmosphere was, at first, almost as bright as the last glimpse of the Sun's limb, but it was different altogether. It was brightest at the sharp limb of the planet, of a different colour to the Sun's limb, and faded off at its outer border. It was less than one second of arc broad, but might, perhaps, have appeared a little broader had there been no cloud.

I now replaced the micrometer, and measured the distance between the cusps.

Replacing the negative eye-piece (210), I again saw the illumination in Venus' atmosphere, but only on the upper or south portion of that part of the planet which was outside the Sun. (I was sitting on the south side of the eye-piece, facing north, the eye-piece being slightly inclined upwards.) It seemed to start from the Sun's limb, and to extend some 60° or 70° along the south limb of Venus, about half a second of arc broad, distinctly visible, though faint. On the other part of the emerged half of Venus I could not detect the slightest trace of this illumination, which I attribute to the effect of cloud; but, from the persistency of the illumination on the south side, it must have been very much brighter there than around the rest of the emerged part. Later, its connexion with the Sun's limb ceased, but it still remained visible.

At 19h. 45m. or 46m. I lost all trace of it.

During the observation of internal contact the wedge was used at about one-fourth its length from the thin end. The brightness of the image was somewhat less than the standard I had in my mind, but I saw best as it was. I shifted it small quantities repeatedly.

At external contact I last saw the planet's sharp limb at 19h. 50m. 25s. by chronometer.

Collecting the various times given, we have—

		h.	m.	s.	
1.	First suspicion of shadow	19	30	7	by chronometer.
2.	Shadow decided	19	30	11	"
3.	Sun's limb obscured	19	30	20	"
4.	External contact	19	50	25	"

We therefore get finally for times of contacts—

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	19	30	7	12	32	13·23	19	30	13·68	8	1	0·80
2.	19	30	11	12	32	17·24	19	30	17·68	8	1	4·80
3.	19	30	20	12	32	26·26	19	30	26·68	8	1	13·80
4.	19	50	25	12	52	34·58	19	50	31·70	8	21	18·82

Whence the equations—

$$
\begin{aligned}
1.\ & 6''\!\cdot576 = 2\cdot251\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t \\
2.\ & 6\cdot784 = 2\cdot251\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t \\
3.\ & 7\cdot257 = 2\cdot251\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot430\,\delta\Delta - 0\cdot052\,\delta t \\
4.\ & 7\cdot642 = 2\cdot122\,\delta\pi + \delta R + \delta\rho + 0\cdot854\,\delta\alpha - 0\cdot381\,\delta\Delta - 0\cdot055\,\delta t
\end{aligned}
$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Lieut. G. E. Coke.

Observed with a 4½-inch Cooke equatoreal; power 215. A solar diagonal and dark wedge, precisely similar to the arrangement on the 6-inch telescope, were used. Times noted by chronometer Molyneux.

EGRESS.

I was seated on the south side of the telescope, the eye-piece being horizontal. The rice grains on the Sun were distinctly visible.

My wife counted seconds from the chronometer, and Mr. White, of the New Zealand Telegraph service, recorded the time, taking the second from myself and the minute from Mr. Hamilton, of the "Lyttleton Times."

At 7 a.m., December 7, I brought the chronometer Molyneux into my equatoreal hut from its usual position in the electric house, it having been already compared by Col. Tupman, and rehearsed a few imaginary observations to see that my assistants thoroughly understood what each was to do. I instructed Mr. White to write in note book, "First disturbance suspected;" against this the first time given was to be placed, and the word "right" added if my suspicion was correct.

When Venus arrived within about a quarter of her diameter from the Sun's limb, I began intently watching the space dividing the limbs, and on the first suspicion of the slightest disturbance of the illumination of the Sun, I took the time, 19h. 28m. 43s., by chronometer, and, as this shadow became more decided, I told Mr. White to place "right" against this time.

At 19h. 29m. 4s. by chronometer this shadow was decided, and about at its darkest, but it never approached in the slightest degree to the darkness of the planet; it was never more than a hazy shadow.

At 19h. 29m. 12s. by chronometer the limbs of Venus and the Sun appeared to be in geometrical contact, the dark body of Venus appearing to just touch the outline of the Sun, which was sharp and well defined. I saw no appearance of an atmosphere of Venus, except the slight shadow disturbing the illumination of the Sun before contact. The limbs of both Venus and the Sun were fairly steady.

At external contact I took the time, 19h. 49m. 45s. by chronometer, when I ceased to observe any break in the Sun's limb; but I do not think that this observation admits of much accuracy.

The Sun was covered by light cirrus clouds which became denser near contact. Fortunately they cleared sufficiently just before contact to allow of a good observation being made.

Collecting the various times, we have—

	h.	m.	s.	
1. First disturbance suspected -	19	28	43	by chronometer.
2. Shadow darkest - - -	19	29	4	,,
3. Geometric contact - - -	19	29	12	,,
4. External contact - -	19	49	45*	,,

We therefore have for times of contacts—

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	19	28	43	12	32	1·69	19	30	2·17	8	0	49·29
2.	19	29	4	12	32	22·74	19	30	23·17	8	1	10·29
3.	17	29	12	12	32	30·77	19	30	31·17	8	1	18·29
4.	19	49	45	12	52	7·22	19	51	4·25	8	21	51·37*

Whence the equations—

$$
\begin{aligned}
1.\ 5''{\cdot}980 &= 2{\cdot}252\,\delta\pi + \delta R - \delta\rho + 0{\cdot}833\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}052\,\delta t \\
2.\ 7{\cdot}069 &= 2{\cdot}251\,\delta\pi + \delta R - \delta\rho + 0{\cdot}834\,\delta\alpha - 0{\cdot}430\,\delta\Delta - 0{\cdot}052\,\delta t \\
3.\ 7{\cdot}499 &= 2{\cdot}251\,\delta\pi + \delta R - \delta\rho + 0{\cdot}834\,\delta\alpha - 0{\cdot}429\,\delta\Delta - 0{\cdot}052\,\delta t \\
4.\ 9{\cdot}418^* &= 2{\cdot}119\,\delta\pi + \delta R + \delta\rho + 0{\cdot}854\,\delta\alpha - 0{\cdot}379\,\delta\Delta - 0{\cdot}055\,\delta t
\end{aligned}
$$

NEW ZEALAND.—NELSON.

	h.	m.	s.	
Longitude of the station - -	11	33	7·82	E. of Greenwich.
Latitude ,, ,, - -	41°	17′	1″·9	S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. A. S. Atkinson.

Observed with a 4-inch Browning refractor, 5 feet focal length; power 167. First surface reflecting prism and dark wedge, with which I made the field of just comfortable brightness. With the eye-piece either pushed in or pulled out a good way a bright star presents a large circular disc, not sharply defined, but circular. Sirius or Canopus shows also concentric dark rings on the disc, which within focus is edged with purplish violet light, and without with greenish yellow. Venus in focus has commonly a violet edging, especially with low powers. I have well divided 52 Orionis, and more easily the larger pairs in ζ and λ, and I have easily seen the companion of Rigel in unsteady air and with the full Moon shining in a clear sky a little below Aldebaran. The air here, in my experience, is commonly unsteady, but on the majority of days very translucent. I followed Well's Comet up to and including August 9, though Venus was awkwardly near, and my lowest power was 50; then bad weather intervened, and I could not recover it afterwards among the small nebulæ in Virgo, my telescope not being an equatoreal. On ordinary days and on the morning of the transit I saw the granulations, by which I understand the general dark mottling of the Sun's surface. Times noted by chronometer Porthouse.

EGRESS.

7 December 1882. Clear sky, but air not steady, and the Sun's limb considerably agitated, and the planet also, though to a less extent. This agitation was well marked immediately before what I have called inner contact, but it did not interfere with the almost immediately subsequent observation of the planet's form, nor with the planet's limb when showing above the Sun's, for I got a beautifully definite view of it.

* There appears to be something wrong with the time given for external contact; it is 50 seconds later than the mean time of all the New Zealand observers.

When Venus came close to the Sun's limb, so that I judged contact was imminent, I saw that dark waves, as it were, were carried from her across the very narrow intervening portion of the Sun's disc to his limb; narrow symmetrical portions of the preceding limb of the planet seemed to detach themselves and advance to the Sun's limb, and there pass away.

I fixed my eye steadily on the Sun's limb, as nearly centrally to the advancing planet as I could, and the moment I gave the first signal, 7h. 32m. 38s. by chronometer, was the moment I saw that these dark waves, instead of passing away as before, had suddenly adhered, as it were, to the Sun's limb, and had caused "a distinct and permanent discontinuity in its illumination."

As soon as I was satisfied of this distinctness and permanence, and there was no room for doubt,—there was no flickering at all after its first adherence,—I looked below and found to my great surprise that it was not apparently the whole planet that was adherent to the Sun's limb, but a large detached segment of it. Venus herself seemed little, if at all, distorted so far as I could judge, being centrally underneath, but separated by an interval of light, very thin in the central part, but widening of course on each side, only, I should judge, that the upper limb of this *apparent* planet was at least as far—I am satisfied was farther—from the limb of the Sun than the limb of the undivided planet was some seconds earlier.

Having quickly taken this general view, I turned my attention to the dividing light at its thinnest part. The *apparent planet* seemed to press upward and curve in; the chord of the segment and the two bodies were apparently touching along a considerable part of the under side of the segment, but for a very faint white line between them, though it looked more as if this line were marking their junction than separating them. Still, I watched it as long as it remained. I thought it had disappeared at 7h. 33m. 6s. by chronometer, but it had not, and I was not certain that it had until 7h. 33m. 55s. by chronometer. After giving this last signal I looked up and saw the upper limb of the segment clearly protuberant above the line of the Sun's limb, its contour marked by a very faint line of grey light, and separating the Sun's cusps by a considerable interval,—considerable, I mean, in proportion to the diameter of the planet. I did not attempt a numerical estimate at the moment, but I believe the proportion was about one-third. The notches in the sides of the planet caused by the, as yet, incomplete junction—incomplete, that is, in lateral extent—between the apparent planet and the segment were still distinctly visible beneath the limbs of the Sun, that is, on his disc. I should say that in darkness of colour the segment was absolutely indistinguishable both from what the fore part of the planet had been before division and from the rest of it after division.

I left the telescope, described shortly to my assistants what I had seen, and in illustration made an elementary diagram of the appearance and position of the segment when I first discovered its separate existence. I asked Mr. M. W. Richmond, who had been calling time for me, to look for himself, and I adjusted the telescope for him; and even after this the remains of the notches were still visible, though a good deal blurred, being then almost on the Sun's limb, and he saw them.

When these notches were filled up, and Venus was to the extent of perhaps one-third of her perpendicular diameter off the Sun, the part still on the Sun was evidently distorted, being somewhat pear-shaped, *i.e.*, like the larger end of a pear, the part of less diameter being that dividing the Sun's cusps. I saw no deformation in the part off the Sun, even when as much as half-way off. The left upper quadrant was beautifully marked by faint grey light along its edge.

I am perfectly satisfied that the time when I saw "the first appearance of any well-"marked and persistent discontinuity in the illumination of the apparent limb of the "Sun near the point of contact" was, as I have said, 7h. 32m. 38s. ± some moderate fraction of a second. The discontinuity was established with considerable suddenness, so that one slow to make up his mind could not be in doubt more than a small fraction of a second; (it was not a question of doubt at all, but of how long it took to perceive the change. I passed direct from state of mind "it is going to happen" to the state "it has happened" without going through the often intermediate one "I wonder whether it has happened." The passage, if not instantaneous, was a very short one), and the limits of error in recording could not, I think, be wide. While observing I held a stop watch in my hand, which on making my first observation I set going, at the same time calling the second I fixed on (7h. 32m.) 38s. When I first thought I saw the "dividing light" disappear I stopped it, and gave the second signal (7h. 33m.) 6s. On subsequent examination the watch showed exactly the recorded interval, 28 seconds.

I am also quite satisfied, though this is rather inference than testimony, except so far as it records the contemporaneous effect on my own mind, that the segment was in fact the preceding limb and fore part of the planet, and the optical or other illusion took effect in forming and retarding the apparent planet. I think that is the legitimate inference from the facts I have stated, viz. :—

That when I first saw the apparent planet, its preceding limb was farther from the Sun's limb than the limb of the undivided planet had been some seconds earlier.

That the segment caused and maintained a perfect discontinuity in illumination.

That the segment was altogether indistinguishable in darkness and, so far as it went, in form from the planet.

That the line of disappearance of the dividing light was considerably below the preceding limb of the segment, so that I had distinctly to look up from the former to the latter, which was then well above the Sun's limb and there well defined.

For outer contact I fixed my attention on the lower part of the planet, and so gave a certainly premature signal (7h. 51m. 47s.). After this I watched the apparent limb of the Sun, which was trembling considerably. I thought contact had occurred at 7h. 52m. 9s., but continued watching, and 7h. 52m. 25s. I saw a minute hollow on the part of the limb I was watching suddenly filled up and straightened in a way that seemed to me quite different from the wave-like motion of the rest of the limb. This is the way it struck me at the time. If I had to fix on one time for this contact I should take the last; it must be certainly, so far as I can speak, within the limits of the two last. But I should attach little weight to either time singly, except so far as it might be confirmed by other observers; and I would say of the whole observation of outer contact that it did not at the time, and does not now, carry one-fourth part of the conviction to my own mind, of having seen what I was looking for, which I felt on seeing what I have called inner contact.

Collecting the times relating to the contacts, taking last time for external contact, we have—

	h.	m.	s.	
1. Inner contact - - -	7	32	38	by chronometer.
2. Outer contact - - -	7	52	25	,,

We therefore have—

EGRESS.

	Chronometer Time.			Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	7	32	38	12	36	30·04	19	40	28·52	8	1	22·61
2.	7	52	25	12	56	20·26	20	0	15·49	8	21	9·58

Whence the equations—

$$1. \quad 7''\!\cdot\!674 = 2\cdot254\ \delta\pi + \delta R - \delta\rho + 0\cdot834\ \delta\alpha - 0\cdot430\ \delta\Delta - 0\cdot052\ \delta t$$
$$2. \quad 7\cdot104 = 2\cdot128\ \delta\pi + \delta R + \delta\rho + 0\cdot853\ \delta\alpha - 0\cdot382\ \delta\Delta - 0\cdot055\ \delta t$$

NEW ZEALAND.—DUNEDIN.

The longitude of the station, by exchange of signals with Col. Tupman, given in Mr. Beverly's report is 7m. 10·7s. W. of Burnham, it is therefore—

h. m. s.
11 22 2·18 E. of Greenwich.

The latitude also supplied by Mr. Beverly is—

$45^\circ\ 52'\ 20''$ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. A. Beverly.

Observed with a 3-inch telescope; power 100. The telescope, equatoreally mounted, defines well; distinctly separates the components of ζ Aquarii in any

ordinary state of the atmosphere. About the time of internal contact the granular structure of the Sun was plainly visible, especially near the spot cluster. At the time of external contact the Sun had just emerged from a haze in the upper atmosphere, and the definition was less perfect. Times noted by chronometer Arnold and Dent 628.

Egress.

At 7h. 30m. 46s. by chronometer the thread of light separating the limbs of the Sun and Venus, having become excessively slender, appeared to part or darken rather suddenly at the point of contact. No appearance of ligament or anything analogous.

At 7h. 30m. 53s. a very faint ruddy line begins to appear between the cusps, which are like fine needle points 6″ or 7″ apart.

At 7h. 31m. 12s. by chronometer ruddy line more distinct, longer and sensibly arched.

7h. 50m. 51s. by chronometer, external contact.

The condition of the atmosphere was all that could be desired. There was nothing of a prolonged or doubtful character about the phenomena at internal contact such as we were led to expect, and there was no appearance of shading off or shadow before the appearance of the cusps, which I take to arise from imperfect definition. The luminous thread became gradually thinner and finer as the planet advanced, until it was clearly obliterated at the first recorded time. Possibly the pink line joining the cusps might have been a second or two sooner had I been on the look out for it. My opinion is that the time of geometric contact falls between the first and second recorded times—nearer the former—for this reason: if the aperture had been larger, the definition being equally good, the luminous thread would have remained entire a little longer, and the pink thread would have appeared a little sooner; in fact, the disappearance of the one and the appearance of the other might have taken place simultaneously. At the third recorded time the planet was well over the Sun's limb.

The time of external contact is given when the last trace of indentation in the solar limb disappears. It appears to me that under favourable conditions it is as definite and reliable as the internal contact.

We therefore have—

Egress.

	Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	7	30	46	12	25	16·59	19	23	17·00	8	1	14·82
2.	7	30	53	12	25	23·61	19	23	24·00	8	1	21·82
3.	7	31	12	12	25	42·66	19	23	43·00	8	1	40·82
4.	7	50	51	12	45	24·88	19	43	22·00	8	21	19·82

Whence the equations—

$$
\begin{array}{lrl}
1. & 7''\!\cdot\!270 = & 2\cdot255\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot428\,\delta\Delta - 0\cdot052\,\delta t \\
2. & 7\cdot634 = & 2\cdot255\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot428\,\delta\Delta - 0\cdot052\,\delta t \\
3. & 8\cdot621 = & 2\cdot253\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot428\,\delta\Delta - 0\cdot052\,\delta t \\
4. & 7\cdot641 = & 2\cdot128\,\delta\pi + \delta R + \delta\rho + 0\cdot854\,\delta\alpha - 0\cdot380\,\delta\Delta - 0\cdot055\,\delta t
\end{array}
$$

Observations of the Contacts of the Sun and Venus.

Mr. R. Gillies.

The telescope used was of 6 inches aperture, and equatoreally mounted, with power used 150.

Egress.

The internal contact at egress came on very gradually, the line of light getting thinner and thinner till it, the line of light, became obscured distinctly and unmistakably, which I took to be the contact, immediately after, possibly two seconds, complete extinction of all light was seen where the thread of light had been, and at the same moment I noticed that the limb of Venus was distinctly beyond the line of the disc of

the Sun; there was a faint grey light on Venus. I would have noted this complete extinction, but, at the moment, I felt so sure of the other being the right contact that I did not note the time. I feel quite satisfied that the time noted is the contact, and only mention the above to account for my not noting the time. The weather was all that could be desired at about the time of contact, though, half an hour before, nothing could be seen of the Sun, and had not been seen all the morning. The thin veil of cloud then got thinner gradually, and at the time of contact, and for 10 minutes before and after the external contact, the definition was as good as I ever saw it, the thin veil of cloud tempering the light, and making both the Sun and Venus sharp and clear. This was specially seen when Venus was half off the Sun, the points of the notch being peculiarly sharp cut. There was no boiling, and no glare or sudden alteration of light, and no motion Venus; the black dot in the surrounding light remained as steady as if stationary without my having to touch shade, focussing screw, or clock strings; everything went easily and right. I was seated in an easy posture with the electric stop in my hand, and had no doubt of my signal. Another person might have differed half a second, not more.

The contact external was not so clear; it simply faded off the disc of the Sun, but seemed to come and go at last. The time I noted was when the limb of the Sun was complete and clear, but immediately after I saw like a darker short line on the edge of the Sun, but it disappeared immediately, and, as something of the same thing appeared before the time I marked, I did not note but the one. I now think that I ought to have noted the last of these, and, therefore, probably the external contact is noted by me too early. No rice grains were seen by me.

After the planet was well on the limb the planet seemed to appear to draw out towards the limb into a pear shape, and I drew Mr. Keys' attention to it, and he looked at it.

The times of contact are—

		h.	m.	s.	
1.	Internal contact	12	22	4·8	by clock and chronograph.
	,, ,,	7	29	27·5	by chronometer.
2.	External contact	12	41	46·4	by clock and chronograph.
	,, ,,	7	49	5·5	by chronometer.

Taking the mean of the times given by clock and chronometer, we get—

EGRESS.

	Local Sidereal Time.			Burnham Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	12	25	11·69	19	30	22·82	8	1	9·94
2.	12	44	53·14	19	50	1·04	8	20	48·16

Whence the equations—

$$1.\ 7''\!\cdot\!020 = 2\cdot256\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot429\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\ 5\cdot908 = 2\cdot132\,\delta\pi + \delta R + \delta\rho + 0\cdot853\,\delta\alpha - 0\cdot381\,\delta\Delta - 0\cdot055\,\delta t$$

NOTE to report on the TRANSIT of VENUS.

By the expression "complete extinction of all light," I do not mean that there was jet black darkness, but that the obscured light which was between the planet and limb of the Sun had become narrower and narrower till it was gone; there always was a sort of radiance or faint light in front of the planet, which now, I have no doubt, was the atmosphere of Venus, though at the time I was too intent upon other things to think what it was. It was this faint light that I saw distinctly beyond the line of the disc of the Sun, and which in my report I call the limb of Venus. At the time I thought it was the planet itself, slightly illuminated. I think now it must have been its atmosphere. The touching of the disc of Venus on the limb of the Sun was quite clear and distinct, and was what I took to be geometric contact, and at the same moment as noted in my report. "I noticed the limb of Venus was distinctly beyond

the limb of the Sun." This is what must have been the atmosphere. I regret I did not note this time as stated in my report.

(Signed) Robert Gillies.

Dunedin, 8th January 1883.

Note.—The telescope was examined by Col. Tupman at Mr. Gillies' request, who considers it to be affected by considerable spherical aberration. The equations of condition have been discussed, both including and excluding Mr. Gillies' observation, but the rejection of the observation scarcely changes the resulting value of the parallax.

---

	h.	m.	s.	
Longitude of the station -	11	21	58·08	E. of Greenwich.
Latitude ,, ,, - -	45°	52′	11″	S.

Observations of the Contacts of the Sun and Venus.

Mr. H. Skey.

Observed with a 9¼-inch Browning reflector, first surface reflecting prism; power 120, and rather pale neutral tint dark head. The telescope shows well the granulations on the Sun, but, owing to the slight cloud, they were not very noticeable during the transit. The disc of a bright star when the eye-piece is pushed in within the focus is perfectly circular, with the round black image of the flat in the centre. The same appearance is presented when the eye-piece is pulled out an equal distance beyond the focus. It divides 170 Canis Minoris easily, also γ Centauri, and is guaranteed to divide μ^2 Boötis. Times noted by chronometer Porthouse by Mr. A. H. Ross. In addition to this, the times shown by an astronomical clock were noted by Mr. J. K. Logan, inspector of telegraphs, and at the completion of the transit the observed difference between clock and chronometer was found to correspond with difference of times noted by the two observers.

Egress.

At 7h. 32m. 1s. by chronometer the limbs of the Sun and Venus seemed to make a vibratory approach towards each other, for the extremely thin thread of light broke, and then joined again four or five times; in other words, thin pointed and well-defined cusps kept forming and then joining.

This flashing lasted three seconds by estimation when a straw coloured shade was observed on the previously white disc of the Sun between the limbs of the Sun and Venus, which rapidly passed through a brown to a nearly black shade, and completely obscured the Sun's limb. At 7h. 32m. 9s. by chronometer, when geometrical internal contact appeared complete, the Sun's limb was permanently discontinuous near the point of contact.

The ligament arising from this contact was of the same shade of darkness as the body of Venus and the background of the sky, that is, nearly black, and no change in this colour was afterwards observed in any part of the ligament. The cusps at this time were now blunted, and, when the leading limb of Venus was well off the Sun's disc, the points of the cusps were cut off by straight shaded lines. No "black drop" was observed, nor did Venus ever assume a "pear shape."

7h. 52m. 16s. by chronometer. Last external contact occurred.

There was a slight haze over the Sun during these observations, the clouds which had obscured the Sun from its first rising not being completely dissolved. This, however, had the effect of wonderfully improving the definition of the limbs of Venus and the Sun, which were noticed to be equal to each other in sharpness of outline.

We have therefore—

Egress.

	Chronometer Time.			Local Sidereal Time.			Burnham Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	7	32	1	12	24	48·50	19	30	3·78	8	0	50·90
2.	7	32	9	12	24	56·52	19	30	11·78	8	0	58·90
3.	7	52	16	12	45	6·83	19	50	18·78	8	21	5·90

Whence the equations—

$$1.\ 6''\!\cdot\!017 = 2\cdot258\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot429\,\delta\Delta - 0\cdot052\,\delta t$$
$$2.\ 6\cdot434 = 2\cdot257\,\delta\pi + \delta R - \delta\rho + 0\cdot834\,\delta\alpha - 0\cdot429\,\delta\Delta - 0\cdot052\,\delta t$$
$$3.\ 6\cdot882 = 2\cdot130\,\delta\pi + \delta R + \delta\rho + 0\cdot854\,\delta\alpha - 0\cdot380\,\delta\Delta - 0\cdot055\,\delta t$$

NEW ZEALAND.—NEW PLYMOUTH.

		h.	m.	s.	
Longitude of the station	-	11	36	17·55	E. of Greenwich.
Latitude „ „	- -	39°	4′	0″·8	S.

Observations of the Contacts of the Sun and Venus.

Mr. T. Humphries.

Observed with a 4-inch telescope by Cooke; power 200. Times noted by a chronometer by Mr. T. K. Skinner. The telescope is a very good one, and with the power 200 gave fair definition, and granulations were plain on the Sun's surface.

Egress.

h.	m.	s.		
7	37	17	by chronometer.	Joined, light haze.
7	37	30	„ „	Contact. Might have been a second earlier; should say certainly to two seconds; under rather than over.
7	37	56	„ „	Limb of Venus outside, and distinct ring of light on it.

I used the word joined to distinguish it from "contact." A dark haze appeared between the limbs, which I thought was going to merge into "black drop," but five seconds after I called "off again," as clear light appeared.

There were passing clouds throughout the morning, and the Sun was obscured for some minutes previous to 7h. 33m., when it cleared. At 7h. 34m. I have noted "great vibration," and at 7h. 36m. steady again.

The appearance at contact was not as clear and marked as I should have wished, as for a moment or two previous the band of clear sunlight seemed to flicker between the limbs, but was shut off instantaneously. This was the time I took for contact.

We get for time of contact therefore—

Egress.

Chronometer Time.			Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
7	37	30	12	39	45·76	19	40	34·49	8	1	28·58

Whence the equation—

$$7''\!\cdot\!963 = 2\cdot256\,\delta\pi + \delta R - \delta\rho + 0\cdot833\,\delta\alpha - 0\cdot431\,\delta\Delta - 0\cdot052\,\delta t$$

The latitude of the station is assumed to be 39° 3′ 57″ S.; the longitude the same as Mr. Humphries' station.

Observations of the Contacts of the Sun and Venus.

Mr. A. O. N. O'Donahoo.

Observed with a 2⅝-inch telescope by Elliott Bros.; power 110. The neutral-coloured glass used gave a bright and distinct image, enabling me to speak confidently as to the time of the appearance of contact within a couple of seconds.

EGRESS.

h. m. s.
7 37 44 by watch. No drop; no granulations visible. No phenomenon of any kind whatever on the surface of the Sun.

The contact might have been one second later than the time given; it was a pure geometrical one, with very good definition. There was no haze of any description at the time of contact.

Mr. O'Donahoo's watch was *fast* of Mr. Humphries' chronometer—

	h.	m.		s.
At	19	0	- -	18·0
,,	20	15	- -	17·0

We therefore have—

EGRESS.

Watch Time.			Local Sidereal Time.			Mount Cook Mean Time.			Greenwich Mean Time.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
7	37	44	12	39	42·25	19	40	30·99	8	1	25·08

Whence the equation—

$$7''\!\cdot\!791 = 2\cdot256\ \delta\pi + \delta R - \delta\rho + 0\cdot833\ \delta\alpha - 0\cdot431\ \delta\Delta - 0\cdot052\ \delta t$$

HOBART.

	h.	m.	s.
Adopted longitude of the station -	9	49	19·53* E. of Greenwich.
Latitude - - - -	42°	53′	24″ S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. E. J. White.

Observed with a 4½-inch Cooke equatoreal, negative eye-piece; power 200, with Herschel's prism and neutral glass wedge. The grainy structure of the Sun was not perceptible, but tolerable definition of a scattered group of small spots was obtained. Venus did not exhibit any well-marked distortion; the only imperfection of figure was her serrated edges, due to atmospheric disturbance. The remark about the grainy structure of the Sun applies to about the middle time between the contacts. A few minutes after the last contact the structure was very distinct about the centre of the Sun. Times taken by chronometer Molyneux by Mr. White himself, who also wrote down his own notes; but as each note was entered, Captain Shortt, R.N., who acted as assistant, noted the times by his mean time chronometer as a check against mistakes.

EGRESS.

Sun rose in nearly clear sky behind trees, and was occasionally for the first half hour hid behind stratus clouds. After this the sky was quite free from clouds during the whole of the transit. At 16h. 41m. Sun had risen sufficiently high to be seen over the base of revolving dome, and Venus was well seen, although the images were boiling excessively. Throughout Venus appeared very black about the centre, and dark indigo colour near her edges.

* Mr. White gives 9h. 49m. 20·5s. E. as the longitude of the station; but since receiving the report a new value for Melbourne has been obtained, and, assuming Mr. White's longitude to be founded on the former value of Melbourne, the corrected longitude becomes 9h. 49m. 19·53s. E. of Greenwich.

h.	m.	s.		
10	53	33·8	by chronometer.	Internal contact observed tangentially. Venus serrated, but appeared generally round. No black drop or ligament seen.
10	59	0	,, ,,	Up till this time a ring of light was seen round Venus (the part off the Sun). After this it extended only about three-quarters round the limb off the Sun.
11	2	50	,, ,,	Venus appeared about half off the Sun. Ring of light only seen on apparent right-hand edge, extending about 60°.
11	8	0	,, ,,	No ring visible round Venus.
11	13	25·6	,, ,,	External contact observed at egress.

We have therefore—

EGRESS.

	Chronometer Time.	Local Sidereal Time.	Local Mean Time.	Greenwich Mean Time.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
1. Internal contact	10 53 33·8	10 53 46·00	17 51 46·22	8 2 26·69
2. External contact	11 13 25·6	11 13 37·80	18 11 34·76	8 22 15·23

Whence the equations—

$$1.\quad 8''\!\cdot\!190 = 2\cdot570\ \delta\pi + \delta R - \delta\rho + 0\cdot836\ \delta\alpha - 0\cdot425\ \delta\Delta - 0\cdot052\ \delta t$$
$$2.\quad 7\cdot382 = 2\cdot496\ \delta\pi + \delta R + \delta\rho + 0\cdot855\ \delta\alpha - 0\cdot377\ \delta\Delta - 0\cdot054\ \delta t$$

MELBOURNE OBSERVATORY.

	h. m. s.
Longitude - - - -	9 39 53·83 E. of Greenwich.
Latitude - - -	37° 49′ 53″·4 S.

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. R. L. J. Ellery.

Observed with the 8-inch equatoreal of the Melbourne Observatory; power 230.

EGRESS.

Morning overcast and gloomy at 4 a.m., with S.E. scud and dense clouds. At 17h. there were some signs of clouds breaking, and at 17h. 5m. the Sun broke through clear, showing Venus about four diameters from the Sun's limb. Edges of both Sun and Venus *boiling violently*. No markings on Venus visible. When about 1½ diameters from Sun's limb got measures of distances with double-image micrometer; limbs were, however, very disturbed. Changed eye-pieces and watched for contacts at 17h. 17m. Just before contact there was a flickering junction of the limbs, and then an appearance like *Baily's beads*, quite distinct, but flickering for some seconds. Contact was taken to be when the solar light flickering around the edge of Venus ceased to show broken beads of light, and immediately after a break in the Sun's limb was apparent. As the advancing limb of Venus emerged from the solar disc, a clear thread of silvery light was continued around it,—a *very thin thread*. No markings on Venus. At 17h. 53m. first saw a pale halo, or rather disc, of uniform light, very dim, but with a sharp outline symmetrically surrounding Venus outside Sun's disc. Estimated radius = three diameters of planet, very distinct at 17h. 54m. As the planet passed off the Sun the thread-like illumination of advanced edge of Venus disappeared, except on the right-hand advanced side.

This light continued, but became more contracted but brighter, nearly until external contact. At 17h. 58m. 0s., local mean time, it was quite detached from Sun's limb.

Halo still apparent at 17h. 58m., but disappeared at $3\frac{1}{2}$ minutes before external contact.

External contact. Edge of Sun disturbed, but the discontinuity of limb caused by planet well marked until time given, when the undulations on the edge of Sun assumed one uniform character all around. The *boiling* prevented anything like a precise geometric contact, but at the same time the phenomena were marked with considerable clearness by the want of uniformity or otherwise of the regular undulations around the Sun's disc.

Mr. Ellery's times are—

EGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1. First contact -	10	44	40·80	17	42	40·96	8	2	47·13
2. Distinct break in Sun's limb	10	44	50·64	17	42	50·78	8	2	56·95
3. Last contact -	11	4	9·15	18	2	6·12	8	22	12·29

Whence the equations—

$$
\begin{array}{ll}
1. & 8''\!\cdot\!517 = 2\cdot652\ \delta\pi + \delta R - \delta\rho + 0\cdot835\ \delta\alpha - 0\cdot426\ \delta\Delta - 0\cdot052\ \delta t \\
2. & 9\cdot043 = 2\cdot652\ \delta\pi + \delta R - \delta\rho + 0\cdot835\ \delta\alpha - 0\cdot426\ \delta\Delta - 0\cdot052\ \delta t \\
3. & 6\cdot356 = 2\cdot595\ \delta\pi + \delta R + \delta\rho + 0\cdot854\ \delta\alpha - 0\cdot379\ \delta\Delta - 0\cdot054\ \delta t
\end{array}
$$

OBSERVATIONS of the CONTACTS of the SUN and VENUS.

Mr. J. E. Gilbert.

Observed with a $4\frac{1}{2}$-inch Simms' equatoreal; power 140.

EGRESS.

Caught first glimpse of Venus on Sun's disc at 17h. 3m. (mean time). Its form was very much blurred and boiling; colour blue furthest edge from Sun's limb, and purple nearest edge, centre deep violet; Sun's limb boiling; the objects gradually improving in appearance, the Sun's limb the most. At three minutes before contact a narrow luminous halo surrounded the planet, its form improving wonderfully, being almost circular, the boiling very trifling. Gave two (2) dots on chronograph, the first when a *Chinaman's cap* first formed; the second, apparent *contact of limbs*. Gave dots after. The outline of the planet could be traced by a faint but sharply-defined luminous edge, until it was about three parts off the Sun. The edge of the Sun was still boiling at time of last contact.

The times given are—

EGRESS.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1. First contact -	10	44	42·38	17	42	42·54	8	2	48·71
2. Last contact -	11	3	59·63	18	1	56·63	8	22	2·80

Whence the equations—

$$
\begin{array}{ll}
1. & 8''\!\cdot\!605 = 2\cdot652\ \delta\pi + \delta R - \delta\rho + 0\cdot835\ \delta\alpha - 0\cdot426\ \delta\Delta - 0\cdot052\ \delta t \\
2. & 5\cdot845 = 2\cdot595\ \delta\pi + \delta R + \delta\rho + 0\cdot854\ \delta\alpha - 0\cdot379\ \delta\Delta - 0\cdot054\ \delta t
\end{array}
$$

NEW SOUTH WALES.—WENTWORTH.

		h.	m.	s.	
Longitude of the station	- -	9	27	37·18	E. of Greenwich.
Latitude „ „	-	34°	6′	24″·7	S.

Observations of the Contacts of the Sun and Venus.

Mr. C. Todd, C.M.G.

Observed with an excellent equatoreal, having $4\frac{1}{2}$ inches aperture, purchased from the late Mr. B. H. Babbage, who brought it from England after the death of his father the late Mr. C. Babbage, to whom it formerly belonged.

Egress.

The Sun rose in an unclouded sky on the day of the transit, and the circumstances were all one could desire. Near the time of internal contact the limb of Venus became somewhat distorted or slightly drawn out towards the edge of the Sun, and it was rather woolly; the Sun's limb too was occasionally boiling, but I think I succeeded in getting the times of the different phases as exact as the nature of the observation will admit.

1. December 6d. 17h. 30m. 15s., Wentworth mean time. A few excessively thin ligaments appeared at this instant to connect the limb of the planet with that of the Sun, and the streak of light round the limb was never again sensibly continuous, although the planet was well on the Sun.

2. 17h. 30m. 58·6s. The ligaments, which have been gradually thickening since the last time noted, have now closed, and the contact now seems tangential.

17h. 32m. 7h. The appearance was very much as shown in enclosed rough sketch. Evidently partly off limb now.

17h. 50m. 7s. Sun's limb seems to be still slightly notched.

3. 17h. 50m. 17s. Limb perfect. Noted for external contact.

I should mention that the planet when well on the Sun was sensibly oval, and appeared of a greyish black colour.

Collecting the times relating to the transit, we have—

Egress.

	Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
	h.	m.	s.	h.	m.	s.	h.	m.	s.
1.	10	32	14·82	17	30	15·00	8	2	37·82
2.	10	32	58·54	17	30	58·60	8	3	21·42
3.	10	52	20·11	17	50	17·00	8	22	39·82

Whence the equations—

$$
\begin{aligned}
1.\quad 7''\!\cdot\!578 &= 2\cdot705\,\delta\pi + \delta R - \delta\rho + 0\cdot835\,\delta\alpha - 0\cdot427\,\delta\Delta - 0\cdot052\,\delta t\\
2.\quad 9\cdot831 &= 2\cdot704\,\delta\pi + \delta R - \delta\rho + 0\cdot835\,\delta\alpha - 0\cdot425\,\delta\Delta - 0\cdot052\,\delta t\\
3.\quad 7\cdot256 &= 2\cdot659\,\delta\pi + \delta R + \delta\rho + 0\cdot854\,\delta\alpha - 0\cdot379\,\delta\Delta - 0\cdot054\,\delta t
\end{aligned}
$$

NEW ZEALAND.—AUCKLAND.

The position of Captain Heale's station has been kindly supplied by Mr. McKerrow, Surveyor-General of New Zealand, viz.:—

The longitude given is 9m. 56·52s. E. of Burnham; therefore it is—

h. m. s.
11 39 9·40 E. of Greenwich.

The latitude determined by Mr. Adams is—

36° 51′ 9″·6 S.

Observations of the Contacts of the Sun and Venus.

Captain T. Heale.

Observed with a 5-inch refractor, 6 feet focal length, equatoreally mounted on a brick pedestal; power 115.

Egress.—External Contact.

About 6 in the morning the planet was seen very clearly on the Sun's disc, but as she approached the limb the low misty stratus cloud, which more or less covered the whole heavens, thickened, and the Sun was not seen. At 12h. 48m., sidereal time, the planet was seen through the thin mist clearly, but without dark glass, her image, as well as the Sun's limb, perfectly well-defined and without the least distortion; the cusps of light quite sharp. It continued to be seen quite clearly till exit. At first there was so little brightness that I found it necessary to use a low power (115) in order to get sufficient light. When near the external contact it became brighter, and I should have been glad to have had a rather higher power, but I was afraid to shift the eye-piece.

At 13h. 2m. 45s. by chronometer I could still distinctly see the indentation of the Sun's limb; two seconds later its appearance became doubtful, and at 49s. the edge of the limb was *certainly* perfectly uniform. I noted the last time as that of the contact, but possibly one second earlier may be the true time. It is *certainly* true within *two* seconds. I therefore take as the moment of separation—

h.	m.	s.	
13	2	48	by chronometer.

Captain Heale gives his chronometer at time of the transit 35s. fast of local mean time. We therefore get—

Egress.—External Contact.

Chronometer Time.			Local Sidereal Time.			Local Mean Time.			Greenwich Mean Time.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
13	2	48	13	2	13·00	20	0	10·18	8	21	0·78

Whence the equation—

$$6''.594 = 2\cdot131\ \delta\pi + \delta R + \delta\rho + 0\cdot852\ \delta\alpha - 0\cdot384\ \delta\Delta - 0\cdot055\ \delta t$$

RESIDUAL EQUATIONS AND DISCUSSION OF INGRESS OBSERVATIONS.

Ingress.—Observations near "External" Contact.

Collecting the results and arranging them in order of their parallax factors we have, taking the earliest times at which Venus was seen as the time of external contact, the following equations of condition:—

Station.	Observer.	Equation of Condition with Adopted Data.	Residual.
1. Mauritius - -	Dr. C. Meldrum - -	$5''.836 = -2\cdot160\ \delta\pi + \delta s$	$+0''.243$
2. Madagascar -	Commander P. Aldrich -	$6\cdot989 = -1\cdot998\ \delta\pi + \delta s$	$+1\cdot410$
3. Aberdeen Road, Cape of Good Hope.	Mr. Finlay - -	$4\cdot086 = -1\cdot774\ \delta\pi + \delta s$	$-1\cdot473$
4.	Mr. Pett - - -	$3\cdot929 = -1\cdot774\ \delta\pi + \delta s$	$-1\cdot630$
5. Montagu Road, Cape of Good Hope.	Mr. Marth - -	$5\cdot404 = -1\cdot683\ \delta\pi + \delta s$	$-0\cdot147$
6.	Mr. Stevens - -	$7\cdot263 = -1\cdot683\ \delta\pi + \delta s$	$+1\cdot712$

Station.	Observer.	Equation of Condition with Adopted Data.	Residual.
7. Cape of Good Hope, Royal Observatory.	Dr. Gill - -	$4''.933 = -1.658\,\delta\pi + \delta s$	$-0''.615$
8.	Dr. Elkin - - -	$2.087 = -1.658\,\delta\pi + \delta s$	-3.461
9.	Mr. Pillans - -	$6.342 = -1.658\,\delta\pi + \delta s$	$+0.794$
10.	Captain Jurisch - -	$7.546 = -1.658\,\delta\pi + \delta s$	$+1.998$
11. Strait of Magellan -	Captain Wharton -	$6.864 = -0.625\,\delta\pi + \delta s$	$+1.409$
12. Barbados - -	Lieut. Thomson - -	$6.566 = +1.929\,\delta\pi + \delta s$	$+1.341$
13. Jamaica - -	Dr. Copeland - -	$4.539 = +2.278\,\delta\pi + \delta s$	-0.655
14.	Captain Mackinlay -	$4.009 = +2.278\,\delta\pi + \delta s$	-1.185
15.	Mr. Hall - -	$4.917 = +2.296\,\delta\pi + \delta s$	-0.275
16. Bermuda - -	Mr. Plummer - -	$4.984 = +2.455\,\delta\pi + \delta s$	-0.194
17.	Lieut. Neate - -	$5.319 = +2.455\,\delta\pi + \delta s$	$+0.141$
18. Ottawa - -	Mr. Blake - - -	$5.747 = +2.697\,\delta\pi + \delta s$	$+0.591$

Solving the above by the method of least squares, we find—

$$\delta\pi = -0''.090$$

and—

$$\delta s = 5''.399$$

Therefore—

$$\pi = 8''.760 \pm 0''.122$$

The separation of the centres of Venus and Sun at this phase is—

$$1001''.1$$

If we exclude the observation of Dr. Elkin, we have—

	Equations of Condition with Adopted Data.	Residual.
1.	$5''.836 = -2.160\,\delta\pi + \delta s$	$-0''.141$
2.	$6.989 = -1.998\,\delta\pi + \delta s$	$+1.040$
3.	$4.086 = -1.774\,\delta\pi + \delta s$	-1.824
4.	$3.929 = -1.774\,\delta\pi + \delta s$	-1.981
5.	$5.404 = -1.683\,\delta\pi + \delta s$	-0.490
6.	$7.263 = -1.683\,\delta\pi + \delta s$	$+1.369$
7.	$4.933 = -1.658\,\delta\pi + \delta s$	-0.957
9.	$6.342 = -1.658\,\delta\pi + \delta s$	$+0.452$
10.	$7.546 = -1.658\,\delta\pi + \delta s$	$+1.656$
11.	$6.864 = -0.625\,\delta\pi + \delta s$	$+1.154$
12.	$6.566 = +1.929\,\delta\pi + \delta s$	$+1.301$
13.	$4.539 = +2.278\,\delta\pi + \delta s$	-0.665
14.	$4.009 = +2.278\,\delta\pi + \delta s$	-1.195
15.	$4.917 = +2.296\,\delta\pi + \delta s$	-0.284
16.	$4.984 = +2.455\,\delta\pi + \delta s$	-0.190
17.	$5.319 = +2.455\,\delta\pi + \delta s$	$+0.145$
18.	$5.747 = +2.697\,\delta\pi + \delta s$	$+0.616$

From which we get—

$$\delta\pi = -0''.174$$
$$\delta s = 5.601$$

Therefore—

$$\pi = 8''.676 \pm 0''.106$$

INGRESS.—RESIDUAL ERRORS from TIMES observed near the INTERNAL CONTACT.

	Station.	Observer.	Equations of Condition.
1.	Mauritius - -	Dr. Meldrum - -	$3''.022 = -2.142\ \delta\pi + \delta s$
2.	Madagascar -	Rev. S. J. Perry -	$-0.782 = -2.003\ \delta\pi + \delta s$
3.			$2.837 = -2.003\ \delta\pi + \delta s$
4.			$3.402 = -2.003\ \delta\pi + \delta s$
5.		Rev. W. Sidgreaves -	$1.223 = -2.003\ \delta\pi + \delta s$
6.			$2.493 = -2.003\ \delta\pi + \delta s$
7.			$2.740 = -2.003\ \delta\pi + \delta s$
8.		Commander P. Aldrich -	$1.371 = -2.003\ \delta\pi + \delta s$
9.			$2.977 = -2.003\ \delta\pi + \delta s$
10.	Durban - -	Mr. Neison - -	$3.225 = -1.903\ \delta\pi + \delta s$
11.	Aberdeen Road, Cape of Good Hope.	Mr. Finlay - -	$-0.689 = -1.824\ \delta\pi + \delta s$
12.			$2.999 = -1.827\ \delta\pi + \delta s$
13.		Mr. Pett - -	$3.201 = -1.827\ \delta\pi + \delta s$
14.	Montagu Road, Cape of Good Hope.	Mr. Marth - -	$1.519 = -1.743\ \delta\pi + \delta s$
15.			$3.159 = -1.745\ \delta\pi + \delta s$
16.		Mr. Stevens - -	$-0.560 = -1.741\ \delta\pi + \delta s$
17.			$1.477 = -1.743\ \delta\pi + \delta s$
18.			$[3.118] = -1.745\ \delta\pi + \delta s$
19.	Cape of Good Hope, Royal Observatory.	Dr. Gill - - -	$0.895 = -1.722\ \delta\pi + \delta s$
20.			$2.664 = -1.723\ \delta\pi + \delta s$
21.			$3.655 = -1.724\ \delta\pi + \delta s$
22.		Mr. Maclear - -	$0.226 = -1.721\ \delta\pi + \delta s$
23.			$2.427 = -1.723\ \delta\pi + \delta s$
24.			$4.339 = -1.724\ \delta\pi + \delta s$
25.		Dr. Elkin - - -	$-0.105 = -1.721\ \delta\pi + \delta s$
26.			$3.063 = -1.723\ \delta\pi + \delta s$
27.			$3.720 = -1.724\ \delta\pi + \delta s$
28.			$3.983 = -1.724\ \delta\pi + \delta s$
29.		Mr. Freeman - -	$2.891 = -1.723\ \delta\pi + \delta s$
30.			$3.753 = -1.724\ \delta\pi + \delta s$
31.		Mr. Pillans - -	$2.014 = -1.723\ \delta\pi + \delta s$
32.			$2.382 = -1.723\ \delta\pi + \delta s$
33.			$4.015 = -1.724\ \delta\pi + \delta s$
34.		Captain Jurisch -	$1.914 = -1.723\ \delta\pi + \delta s$
35.			$3.216 = -1.724\ \delta\pi + \delta s$
36.			$4.063 = -1.724\ \delta\pi + \delta s$
37.	Strait of Magellan -	Captain Wharton - -	$1.840 = -0.745\ \delta\pi + \delta s$
38.			$3.339 = -0.749\ \delta\pi + \delta s$
39.	Barbados - -	Mr. Talmage - -	$1.631 = +1.843\ \delta\pi + \delta s$
40.		Lieut. Thomson - -	$1.417 = +1.843\ \delta\pi + \delta s$
41.	Jamaica - -	Dr. Copeland - -	$2.941 = +2.195\ \delta\pi + \delta s$
42.		Captain Mackinlay -	$2.310 = +2.196\ \delta\pi + \delta s$
43.		Dr. Pearson - -	$2.942 = +2.197\ \delta\pi + \delta s$

The observations of Mr. Freeman, equations 29 and 30, were made with a power of 74; those of Captain Jurisch, equations 34 to 36, with a telescope whose object-glass was only 2¼ inches in diameter.

Station.	Observer.	Equations of Condition.
44. Jamaica - -	Mr. Hall - -	$3''.203 = +2.215\ \delta\pi + \delta s$
45.		$4.083 = +2.215\ \delta\pi + \delta s$
46.	Mean adopted by Mr. Hall.	$3.643 = +2.215\ \delta\pi + \delta s$
47. Bermuda - -	Mr. Plummer - -	$1.700 = +2.403\ \delta\pi + \delta s$
48.		$2.371 = +2.402\ \delta\pi + \delta s$
49.		$3.049 = +2.402\ \delta\pi + \delta s$
50.	Lieut. Neate - -	$1.390 = +2.403\ \delta\pi + \delta s$
51.		$1.835 = +2.403\ \delta\pi + \delta s$
52.		$2.828 = +2.402\ \delta\pi + \delta s$
53. Cambridge, U.S.A. -	Mr. Jewett - -	$1.324 = +2.615\ \delta\pi + \delta s$
54. Kingston, Canada -	Mr. Williamson - -	$0.211 = +2.672\ \delta\pi + \delta s$
55.		$2.949 = +2.671\ \delta\pi + \delta s$
56. Ottawa, Canada -	Mr. Blake - -	$2.557 = +2.675\ \delta\pi + \delta s$

INGRESS.—INTERNAL CONTACT.

In discussing these equations it will probably be desirable not to include Dr. Elkin's observations (equations 25–28), as it was observed with half the object-glass of a 4-inch heliometer, and, therefore, may be considered to have been made under different circumstances from the rest of the observations. Dr. Elkin's observations, however, agree very closely with the mean results. The times of contacts noted by Mr. Stevens at Montague Road, Cape of Good Hope (equation 17), and by Mr. Talmage, at Barbados (equation 39), are very early, and appear to refer to the phase noted by other observers as "Geometric or Apparent Contact." Including these, we have 13 equations of geometric or apparent contact as follows:—

	Equation of Condition.	Residual.
2.	$-0''.782 = -2.003\ \delta\pi + \delta s$	$-1''.980$
5.	$+1.223 = -2.003\ \delta\pi + \delta s$	$+0.025$
8.	$+1.371 = -2.003\ \delta\pi + \delta s$	$+0.173$
14.	$+1.519 = -1.743\ \delta\pi + \delta s$	$+0.315$
17.	$+1.477 = -1.743\ \delta\pi + \delta s$	$+0.273$
34.	$+1.914 = -1.723\ \delta\pi + \delta s$	$+0.710$
37.	$+1.840 = -0.745\ \delta\pi + \delta s$	$+0.612$
39.	$+1.631 = +1.843\ \delta\pi + \delta s$	$+0.341$
40.	$+1.417 = +1.843\ \delta\pi + \delta s$	$+0.127$
47.	$+1.700 = +2.403\ \delta\pi + \delta s$	$+0.397$
50.	$+1.390 = +2.403\ \delta\pi + \delta s$	$+0.087$
53.	$+1.324 = +2.615\ \delta\pi + \delta s$	$+0.016$
54.	$+0.211 = +2.672\ \delta\pi + \delta s$	-1.098

Which gives—

$$\delta\pi\ +0''.024,$$
$$\text{and}\quad \delta s\quad 1.246.$$

Therefore—

$$\pi = 8''.874 \pm 0''.066.$$

The angular separation of the centres of Venus and the Sun at this phase is about 941″·4. Or, if we reject the observations of Messrs. Stevens (equation 17) and Talmage (equation 39), the equations are—

$$\begin{array}{rrcrcc|r}
 & & & & & & \text{Residual.} \\
2. & -0''\!\cdot\!782 & = & -2\cdot003\,\delta\pi & + & \delta s & -1''\!\cdot\!925 \\
5. & +1\cdot223 & = & -2\cdot003\,\delta\pi & + & \delta s & +0\cdot080 \\
8. & +1\cdot371 & = & -2\cdot003\,\delta\pi & + & \delta s & +0\cdot228 \\
14. & +1\cdot519 & = & -1\cdot743\,\delta\pi & + & \delta s & +0\cdot370 \\
34. & +1\cdot914 & = & -1\cdot723\,\delta\pi & + & \delta s & +0\cdot765 \\
37. & +1\cdot840 & = & -0\cdot745\,\delta\pi & + & \delta s & +0\cdot668 \\
40. & +1\cdot417 & = & +1\cdot843\,\delta\pi & + & \delta s & +0\cdot186 \\
47. & +1\cdot700 & = & +2\cdot403\,\delta\pi & + & \delta s & +0\cdot456 \\
50. & +1\cdot390 & = & +2\cdot403\,\delta\pi & + & \delta s & +0\cdot146 \\
53. & +1\cdot324 & = & +2\cdot615\,\delta\pi & + & \delta s & +0\cdot075 \\
54. & +0\cdot211 & = & +2\cdot672\,\delta\pi & + & \delta s & -1\cdot040
\end{array}$$

Whence—

$$\begin{aligned}\delta\pi &= +0''\!\cdot\!023 \\ \delta s &= 1\cdot189,\end{aligned}$$

or—

$$\pi = 8''\!\cdot\!873 \pm 0''\!\cdot\!081,$$

which agrees very closely indeed with the value obtained before.

Rejecting the observations of Father Perry and Mr. Williamson (equations 2 and 54), which may refer to some other phase, for they agree closely with the contact of limbs as observed by Messrs. Finlay, Stevens, and Elkin (equations 11, 16, and 25), the equations become—

$$\begin{array}{rrcrcc|r}
 & & & & & & \text{Residual.} \\
5. & +1''\!\cdot\!223 & = & -2\cdot003\,\delta\pi & + & \delta s & -0''\!\cdot\!322 \\
8. & 1\cdot371 & = & -2\cdot003\,\delta\pi & + & \delta s & -0\cdot174 \\
14. & 1\cdot519 & = & -1\cdot743\,\delta\pi & + & \delta s & -0\cdot024 \\
17. & 1\cdot477 & = & -1\cdot743\,\delta\pi & + & \delta s & -0\cdot066 \\
34. & 1\cdot914 & = & -1\cdot723\,\delta\pi & + & \delta s & +0\cdot371 \\
37. & 1\cdot840 & = & -0\cdot745\,\delta\pi & + & \delta s & +0\cdot305 \\
39. & +1\cdot631 & = & +1\cdot843\,\delta\pi & + & \delta s & +0\cdot117 \\
40. & 1\cdot417 & = & +1\cdot843\,\delta\pi & + & \delta s & -0\cdot097 \\
47. & 1\cdot700 & = & +2\cdot403\,\delta\pi & + & \delta s & +0\cdot190 \\
50. & 1\cdot390 & = & +2\cdot403\,\delta\pi & + & \delta s & -0\cdot120 \\
53. & 1\cdot324 & = & +2\cdot615\,\delta\pi & + & \delta s & -0\cdot184
\end{array}$$

From which we get—

$$\begin{aligned}\delta\pi &= -0''\!\cdot\!008 \\ \delta s &= 1\cdot529,\end{aligned}$$

or—

$$\pi = 8''\!\cdot\!842 \pm 0''\!\cdot\!028.$$

Finally, rejecting the observations of Father Perry and Mr. Williamson (equations 2 and 54), and also Messrs. Stevens and Talmage (equations 17 and 39), we have—

			Residual.
5.	$+1''\cdot223$	$= -2\cdot003\ \delta\pi + \delta s$	$-0''\cdot334$
8.	$1\cdot371$	$= -2\cdot003\ \delta\pi + \delta s$	$-0\cdot186$
14.	$1\cdot519$	$= -1\cdot743\ \delta\pi + \delta s$	$-0\cdot034$
34.	$1\cdot914$	$= -1\cdot723\ \delta\pi + \delta s$	$+0\cdot361$
37.	$1\cdot840$	$= -0\cdot745\ \delta\pi + \delta s$	$+0\cdot304$
40.	$+1\cdot417$	$= +1\cdot843\ \delta\pi + \delta s$	$-0\cdot076$
47.	$1\cdot700$	$= +2\cdot403\ \delta\pi + \delta s$	$+0\cdot216$
50.	$1\cdot390$	$= +2\cdot403\ \delta\pi + \delta s$	$-0\cdot094$
53.	$1\cdot324$	$= +2\cdot615\ \delta\pi + \delta s$	$-0\cdot156$

From these we get—

$$\delta\pi = -0''\cdot017$$
$$\delta s = \quad 1\cdot524.$$

Therefore—

$$8''\cdot833 \pm 0''\cdot036,$$

which is the smallest result these apparent contacts admit of.

The results from apparent contacts of the atmosphere of Venus and the Sun are, therefore, confined within the limits—

$$\pi = 8''\cdot833 \text{ and } \pi = 8''\cdot874,$$

and the value—

$$\pi = 8''\cdot873 \pm 0''\cdot081$$

is that obtained without the rejection of any observations which profess to be "contacts with the atmosphere of Venus" or "the first appearance of light through the atmosphere of Venus," as distinguished from the "real internal contact."

These contacts appear to have taken place with an angular separation of the centres of Venus and the Sun of about 941″·4.

The principal internal contact to which the observer's attention was directed was defined in the "Instructions" as follows:—

"The time of the last appearance of any well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun near the point of contact."

"The expression '*well-marked* and *persistent* discontinuity in the illumination of the apparent limb of the Sun near the point of contact' is intended to guard observers against giving times for the contacts when there may be a *suspicion* only of some slight disturbance, haze, shadow, or interference phenomena. It is a point of primary importance that all the observers shall, as far as possible, observe the same kind of contact; and it is therefore desirable that the times recorded for contacts should refer to some marked discontinuity in the illumination of the Sun's limb, about which there cannot be a doubt, and which may be supposed to be recognisable by all the observers."

The last times given by the observers at the Royal Observatory, Cape of Good Hope, are very late compared with all the other observations, as will be seen by the following comparison with observations which have parallax factors of the same sign and nearly of the same magnitude.

The residuals for the last recorded times at the Royal Observatory, Cape of Good Hope, are as follows:—

21.	$3''\cdot655$	$= -1\cdot724\ \delta\pi + \delta c$
24.	$4\cdot339$	$= -1\cdot724\ \delta\pi + \delta c$
30.	$3\cdot753$	$= -1\cdot724\ \delta\pi + \delta c$
33.	$4\cdot015$	$= -1\cdot724\ \delta\pi + \delta c$
36.	$4\cdot063$	$= -1\cdot724\ \delta\pi + \delta c$
Mean	$3\cdot965$	$= -1\cdot724\ \delta\pi + \delta c$

Dr. Elkin, who observed with a heliometer, and whose observation is not therefore included with those made with the equatoreals, gives a residual—

$$3''\!\cdot983 = -1\cdot724\,\delta\pi + \delta c.$$

The corresponding residuals for the other stations, neglecting Stevens observation, whose residual is—

$$1''\!\cdot477 = -1\cdot743\,\delta\pi + \delta s,$$

are as follows:—

1.	$3''\!\cdot022 = -2\cdot142\,\delta\pi + \delta s$
Mean 3 and 4.	$3\cdot120 = -2\cdot003\,\delta\pi + \delta s$
7.	$2\cdot740 = -2\cdot003\,\delta\pi + \delta s$
9.	$2\cdot977 = -2\cdot003\,\delta\pi + \delta s$
10.	$3\cdot225 = -1\cdot903\,\delta\pi + \delta s$
12.	$2\cdot999 = -1\cdot827\,\delta\pi + \delta s$
13.	$3\cdot201 = -1\cdot827\,\delta\pi + \delta s$
15.	$3\cdot159 = -1\cdot745\,\delta\pi + \delta s$
38.	$3\cdot339 = -0\cdot749\,\delta\pi + \delta s$
Mean -	$3\cdot087 = -1\cdot800\,\delta\pi + \delta s$

The difference, $0\cdot878, = +0\cdot076\,\delta\pi + \delta c - \delta s$, appears therefore almost entirely due to a difference $\delta c - \delta s$, or difference of phase. Mr. Gill, when in England, was consulted by Mr. Stone in the matter, and in reply sent a letter, of which the following is a copy:—

"When I communicated my report on the Transit of Venus observations made at the Cape Observatory in 1882 I wrote you privately, offering to state what, in my opinion, were the true times of contact. My report naturally had reference solely to official instructions,—instructions which were followed by myself and my assistants as accurately as possible. You now ask that I should communicate the opinion previously offered, and state what I consider to be the true time of contact.

"I have no hesitation in saying that 3h. 25m. 47·5s.,* Cape M.T., represents the phase which would have been followed by a well-marked and persistent discontinuity, if the definition had been good; but there was a south-easter blowing at the time, and, as is usually the case in such circumstances, the images were vibrating rapidly, and definition was very unsatisfactory.

"Thus whilst there remained a 'well-marked and persistent discontinuity in the illumination of the apparent limb of the Sun near the point of contact' till 3h. 26m. 6·9s. C.M.T., which was seen by all the observers at the Cape Observatory, I have no hesitation in saying that this was due to the atmospheric conditions above referred to. The change of colour which I have described at 3h. 25m. 47·5s. is really the only phase that is nearly independent of atmospheric conditions. The phase of 'well-marked and persistent discontinuity of illumination' follows that phase at an interval which is a function of the state of definition. If therefore you reject entirely the Cape Observatory phase 3h. 26m. 6·9s., it will be necessary to reject similar late phases depending upon bad definition in the northern hemisphere.

"You will find on the first page of my Report the phases for the other Cape observers, which, in my opinion, correspond with the above-mentioned phases.

"Yours very truly,
"(Signed) DAVID GILL."

Father Sidgreaves writes that his last recorded time is his "real contact."

A letter from Father Perry states that he wishes the *mean* of his latest times (equations 3 and 4) to be taken as the time of real contact. We therefore have, in accordance with the preceding instructions, and taking last times given by Mr. Plummer

* The observation used in the final equation.

and Lieut. Neate, and including the observations of Messrs. Stevens and Talmage, the following 24 equations:—

	Equation	Residual.
1.	$3''{\cdot}022 = -2{\cdot}142\,\delta\pi + \delta s$	$+0''{\cdot}173$
Mean of 3 & 4.	$3{\cdot}120 = -2{\cdot}003\,\delta\pi + \delta s$	$+0{\cdot}130$
7.	$2{\cdot}740 = -2{\cdot}003\,\delta\pi + \delta s$	$-0{\cdot}107$
9.	$2{\cdot}977 = -2{\cdot}003\,\delta\pi + \delta s$	$+0{\cdot}273$
10.	$3{\cdot}225 = -1{\cdot}903\,\delta\pi + \delta s$	$+0{\cdot}380$
12.	$2{\cdot}999 = -1{\cdot}827\,\delta\pi + \delta s$	$+0{\cdot}155$
13.	$3{\cdot}201 = -1{\cdot}827\,\delta\pi + \delta s$	$+0{\cdot}357$
15.	$3{\cdot}159 = -1{\cdot}745\,\delta\pi + \delta s$	$+0{\cdot}316$
17.	$1{\cdot}477 = -1{\cdot}741\,\delta\pi + \delta s$	$-1{\cdot}366$
20.	$2{\cdot}664 = -1.723\,\delta\pi + \delta s$	$-0{\cdot}179$
23.	$2{\cdot}427 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}416$
29.	$2{\cdot}891 = -1{\cdot}723\,\delta\pi + \delta s$	$+0{\cdot}048$
32.	$2{\cdot}382 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}461$
35.	$3{\cdot}216 = -1{\cdot}723\,\delta\pi + \delta s$	$+0{\cdot}373$
38.	$3{\cdot}339 = -0{\cdot}749\,\delta\pi + \delta s$	$+0{\cdot}511$
39.	$1{\cdot}631 = +1{\cdot}843\,\delta\pi + \delta s$	$-1{\cdot}157$
41.	$2{\cdot}941 = +2{\cdot}195\,\delta\pi + \delta s$	$+0{\cdot}159$
42.	$2{\cdot}310 = +2{\cdot}196\,\delta\pi + \delta s$	$-0{\cdot}472$
43.	$2{\cdot}942 = +2{\cdot}197\,\delta\pi + \delta s$	$+0{\cdot}160$
46.	$3{\cdot}643 = +2{\cdot}215\,\delta\pi + \delta s$	$+0{\cdot}861$
49.	$3{\cdot}049 = +2{\cdot}402\,\delta\pi + \delta s$	$+0{\cdot}270$
52.	$2{\cdot}828 = +2{\cdot}402\,\delta\pi + \delta s$	$+0{\cdot}049$
55.	$2{\cdot}949 = +2{\cdot}671\,\delta\pi + \delta s$	$+0{\cdot}174$
56.	$2{\cdot}557 = +2{\cdot}675\,\delta\pi + \delta s$	$-0{\cdot}218$

From these we get—

$$\delta\pi = -0''{\cdot}0154$$
$$\delta s = 2{\cdot}816,$$

or—

$$\pi = 8''{\cdot}835 \pm 0''{\cdot}035.$$

Rejecting the observations of Messrs. Stevens and Talmage (equations 17 and 39) on the ground of their being "geometrical or apparent contacts," we have—

	Equation	Residual.
1.	$3''{\cdot}022 = -2{\cdot}142\,\delta\pi + \delta s$	$+0''{\cdot}067$
Mean of 3 & 4.	$3{\cdot}120 = -2{\cdot}003\,\delta\pi + \delta s$	$+0{\cdot}023$
7.	$2{\cdot}740 = -2{\cdot}003\,\delta\pi + \delta s$	$-0{\cdot}214$
9.	$2{\cdot}977 = -2{\cdot}003\,\delta\pi + \delta s$	$+0{\cdot}023$
10.	$3{\cdot}225 = -1{\cdot}903\,\delta\pi + \delta s$	$+0{\cdot}272$
12.	$2{\cdot}999 = -1{\cdot}827\,\delta\pi + \delta s$	$+0{\cdot}047$
13.	$3{\cdot}201 = -1{\cdot}827\,\delta\pi + \delta s$	$+0{\cdot}249$
15.	$3{\cdot}159 = -1{\cdot}745\,\delta\pi + \delta s$	$+0{\cdot}208$
20.	$2{\cdot}664 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}287$
23.	$2{\cdot}427 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}524$
29.	$2{\cdot}891 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}060$
32.	$2{\cdot}382 = -1{\cdot}723\,\delta\pi + \delta s$	$-0{\cdot}569$
35.	$3{\cdot}216 = -1{\cdot}723\,\delta\pi + \delta s$	$+0{\cdot}265$
38.	$3{\cdot}339 = -0{\cdot}749\,\delta\pi + \delta s$	$+0{\cdot}399$

	Equation	Residual.
41.	$2''.941 = +1.843\,\delta\pi + \delta s$	$+0''.033$
42.	$2.310 = +2.195\,\delta\pi + \delta s$	-0.598
43.	$2.942 = +2.196\,\delta\pi + \delta s$	$+0.034$
46.	$3.643 = +2.197\,\delta\pi + \delta s$	$+0.735$
49.	$3.049 = +2.215\,\delta\pi + \delta s$	$+0.143$
52.	$2.828 = +2.402\,\delta\pi + \delta s$	-0.078
55.	$2.949 = +2.671\,\delta\pi + \delta s$	$+0.046$
56.	$2.557 = +2.675\,\delta\pi + \delta s$	-0.346

And—

$$\delta\pi = -0''.011$$
$$\delta s = 2.932,$$

or—

$$\pi = 8''.839 \pm 0''.024.$$

If we reject the Cape Observatory observations altogether, the equations would be, retaining the observations of Stevens and Talmage,—

	Equation	Residual.
1.	$3''.022 = -2.142\,\delta\pi + \delta s$	$+0''.104$
Mean of 3 & 4.	$3.120 = -2.003\,\delta\pi + \delta s$	$+0.206$
7.	$2.740 = -2.003\,\delta\pi + \delta s$	-0.174
9.	$2.977 = -2.003\,\delta\pi + \delta s$	$+0.063$
10.	$3.225 = -1.903\,\delta\pi + \delta s$	$+0.314$
12.	$2.999 = -1.827\,\delta\pi + \delta s$	$+0.090$
13.	$3.201 = -1.827\,\delta\pi + \delta s$	$+0.292$
15.	$3.159 = -1.745\,\delta\pi + \delta s$	$+0.253$
17.	$1.477 = -1.741\,\delta\pi + \delta s$	-1.429
38.	$3.339 = -0.749\,\delta\pi + \delta s$	$+0.463$
39.	$1.631 = +1.843\,\delta\pi + \delta s$	-1.168
41.	$2.941 = +2.195\,\delta\pi + \delta s$	$+0.153$
42.	$2.310 = +2.196\,\delta\pi + \delta s$	-0.478
43.	$2.942 = +2.197\,\delta\pi + \delta s$	$+0.154$
46.	$3.643 = +2.215\,\delta\pi + \delta s$	$+0.855$
49.	$3.049 = +2.402\,\delta\pi + \delta s$	$+0.267$
52.	$2.828 = +2.402\,\delta\pi + \delta s$	$+0.046$
55.	$2.949 = +2.671\,\delta\pi + \delta s$	$+0.175$
56.	$2.557 = +2.675\,\delta\pi + \delta s$	-0.217

Whence—

$$\delta\pi = -0''.030$$
$$\delta s = 2.854,$$

and—

$$\pi = 8''.820 \pm 0''.038.$$

With respect to such slight differences of illumination or "last appearances of atmospheric tremor" as those which corresponded to the last recorded times near the internal contact at the Royal Observatory, Cape of Good Hope, such phases do not appear to have been generally seen, or at least generally regarded by the observers as such "well-marked and persistent discontinuities in the illumination of the apparent limb of the Sun near the point of contact" as could be recorded as times of "internal contact." But Mr. Hall's observation at Kempshot Observatory, Jamaica, would, however, appear to be an exception. Mr. Hall's last recorded time would give as wide a separation of the limbs of Venus and the Sun as the last recorded times at the Cape Observatory, and it appears from the observations themselves that at the recorded time, 14h. 13m. 28s., any well-marked disturbance must have ceased.

Following Mr. Hall's instructions we have adopted the mean of the two last recorded times, 14h. 13m. 10s. and 14h. 13m. 28s., as the time of internal contact; but as the corresponding phases at the Cape Observatory have been rejected in accordance with Mr. Gill's wish, and as they should be in accordance with the instructions if they refer to atmosphere tremor, and as 18s. is a very large interval, it appears desirable to adopt the time 14h. 13m. 10s., at which the disturbance of the illumination is very slight. This time cannot, however, be much too late, for at 14h. 13m. 3s., if Mr. Hall's drawing is reliable, the contact was certainly far from over. Adopting therefore the recorded time, 14h. 13m. 10s., for the internal contact at Kempshot Observatory, we have the following 24 equations of condition:—

		Residual.
1.	$3''.022 = -2.142\ \delta\pi + \delta s$	$+0''.169$
Mean of 3 & 4.	$3.120 = -2.003\ \delta\pi + \delta s$	$+0.271$
7.	$2.740 = -2.003\ \delta\pi + \delta s$	-0.109
9.	$2.977 = -2.003\ \delta\pi + \delta s$	$+0.128$
10.	$3.225 = -1.903\ \delta\pi + \delta s$	$+0.378$
12.	$2.999 = -1.827\ \delta\pi + \delta s$	$+0.154$
13.	$3.201 = -1.827\ \delta\pi + \delta s$	$+0.358$
15.	$3.159 = -1.745\ \delta\pi + \delta s$	$+0.316$
17.	$1.477 = -1.741\ \delta\pi + \delta s$	-1.365
20.	$2.664 = -1.723\ \delta\pi + \delta s$	-0.178
23.	$2.427 = -1.723\ \delta\pi + \delta s$	-0.415
29.	$2.891 = -1.723\ \delta\pi + \delta s$	$+0.049$
32.	$2.382 = -1.723\ \delta\pi + \delta s$	-0.460
35.	$3.216 = -1.723\ \delta\pi + \delta s$	$+0.374$
38.	$3.339 = -0.749\ \delta\pi + \delta s$	$+0.523$
39.	$1.631 = +1.843\ \delta\pi + \delta s$	-1.116
41.	$2.941 = +2.195\ \delta\pi + \delta s$	$+0.204$
42.	$2.310 = +2.196\ \delta\pi + \delta s$	-0.427
43.	$2.942 = +2.197\ \delta\pi + \delta s$	$+0.205$
46.	$3.203 = +2.215\ \delta\pi + \delta s$	$+0.466$
49.	$3.049 = +2.402\ \delta\pi + \delta s$	$+0.317$
52.	$2.828 = +2.402\ \delta\pi + \delta s$	$+0.096$
55.	$2.949 = +2.671\ \delta\pi + \delta s$	$+0.224$
56.	$2.557 = +2.675\ \delta\pi + \delta s$	-0.168

From these we get—

$$\delta\pi = -0''.027$$
$$\delta s = \quad 2.796,$$

and—

$$\pi = 8''.823 \pm 0''.034.$$

This result agrees very closely with the value $\pi = 8''.820$, which we find when the observations made at the Royal Observatory, Cape of Good Hope, are not employed in the discussion. The close agreement between these results appears to show that Mr. Gill's selection of the times which correspond to the "internal contact" at the Royal Observatory, Cape of Good Hope, is satisfactory, and that the value—

$$\pi = 8''.823 \pm 0''.034 + 0''.065\ \delta\alpha - 0''.0027\ \delta\Delta$$

may be accepted as the best result which the observations here discussed afford.

RESIDUAL EQUATIONS AND DISCUSSION OF EGRESS OBSERVATIONS.

EGRESS.—RESIDUAL ERRORS from TIMES observed near the INTERNAL CONTACT.

1.	Barbados	Mr. Talmage	$8''{\cdot}122 = -2{\cdot}571\,\delta\pi + \delta s$
2.		Lieut. Thomson	$7{\cdot}155 = -2{\cdot}571$
3.			$7{\cdot}859 = -2{\cdot}571$
4.	Bermuda	Mr. Plummer	$7{\cdot}006 = -2{\cdot}566$
5.			$7{\cdot}819 = -2{\cdot}567$
6.			$8{\cdot}541 = -2{\cdot}567$
7.		Lieut. Neate	$[10{\cdot}235] = -2{\cdot}568$*
8.	Cambridge, U.S.A.	Mr. Sawyer	$6{\cdot}761 = -2{\cdot}404$
9.	Ottawa, Canada	Mr. Blake	$5{\cdot}533 = -2{\cdot}297$
10.			$7{\cdot}556 = -2{\cdot}297$
11.	Kingston, Canada	Mr. Williamson	$7{\cdot}739 = -2{\cdot}295$
12.			$8{\cdot}687 = -2{\cdot}295$
13.	Jamaica	Dr. Copeland	$8{\cdot}119 = -2{\cdot}295$
14.		Capt. Mackinlay	$7{\cdot}888 = -2{\cdot}295$
15.	Jamaica	Dr. Pearson	$7{\cdot}893 = -2{\cdot}295$
16.	Cobourg, Canada	Prof. Bain	$8{\cdot}833 = -2{\cdot}264$
17.	Winnipeg, Canada	Mr. McLeod	$7{\cdot}679 = -1{\cdot}823$
18.	Strait of Magellan	Capt. Wharton	$6{\cdot}161 = +0{\cdot}436$
19.			$7{\cdot}769 = +0{\cdot}440$
20.			$8{\cdot}713 = +0{\cdot}443$
21.		Lieut. Havergal	$6{\cdot}689 = +0{\cdot}437$
22.			$7{\cdot}398 = +0{\cdot}440$
23.	Bidwill's, New Zealand	Mr. Marchant	$7{\cdot}078 = +2{\cdot}214$
24.			$7{\cdot}964 = +2{\cdot}212$
25.			$8{\cdot}535 = +2{\cdot}211$
26.	Wellington, New Zealand	Mr. McKerrow	$7{\cdot}169 = +2{\cdot}225$
27.			$7{\cdot}646 = +2{\cdot}225$
28.			$7{\cdot}965 = +2{\cdot}225$
29.		Mr. Adams	$6{\cdot}560 = +2{\cdot}225$
30.			$7{\cdot}603 = +2{\cdot}225$
31.		Mr. T. King	$5{\cdot}142 = +2{\cdot}230$
32.			$7{\cdot}654 = +2{\cdot}225$
33.			$9{\cdot}490 = +2{\cdot}222$
34.	Christchurch, New Zealand	Mr. Townsend	$7{\cdot}387 = +2{\cdot}246$
35.			$8{\cdot}165 = +2{\cdot}244$

* Approximation only.

36.	Christchurch, New Zealand	Mr. Kitson - -	$6{\cdot}589 = +2{\cdot}248\ \delta\pi + \delta s$
37.			$7{\cdot}741 = +2{\cdot}245$
38.	Burnham, New Zealand -	Col. Tupman - -	$6{\cdot}576 = +2{\cdot}251$
39.			$6{\cdot}784 = +2{\cdot}251$
40.			$7{\cdot}257 = +2{\cdot}251$
41.		Lieut. Coke - -	$5{\cdot}980 = +2{\cdot}252$
42.			$7{\cdot}069 = +2{\cdot}251$
43.			$7{\cdot}499 = +2{\cdot}251$
44.	Nelson, New Zealand -	Mr. Atkinson - -	$7{\cdot}674 = +2{\cdot}254$
45.	Dunedin, New Zealand -	Mr. Beverly - -	$7{\cdot}270 = +2{\cdot}255$
46.			$7{\cdot}634 = +2{\cdot}255$
47.			$8{\cdot}621 = +2{\cdot}253$
48.		Mr. Gillies - -	$7{\cdot}020 = +2{\cdot}256$
49.		Mr. Skey - - -	$6{\cdot}017 = +2{\cdot}258$
50.			$6{\cdot}434 = +2{\cdot}257$
51.	New Plymouth, New Zealand	Mr. Humphries - -	$7{\cdot}963 = +2{\cdot}256$
52.		Mr. O'Donahoo -	$7{\cdot}791 = +2{\cdot}256$
53.	Hobart, New Zealand -	Mr. White - -	$8{\cdot}190 = +2{\cdot}570$
54.	Melbourne - - -	Mr. Ellery - -	$8{\cdot}517 = +2{\cdot}652$
55.			$9{\cdot}043 = +2{\cdot}652$
56.		Mr. Gilbert - -	$8{\cdot}605 = +2{\cdot}652$
57.	Wentworth, New South Wales.	Mr. Todd - - -	$7{\cdot}578 = +2{\cdot}705$
58.			$9{\cdot}831 = +2{\cdot}704$

The observations of internal contact at egress are somewhat difficult to deal with. The observers at some stations have given only *one* time, while others have given *two* and in some cases *three* times, and it is not easy to satisfactorily decide which of the times, when there is more than one given, corresponds to those where only single times are given; the equations, therefore, have been solved by the method of least squares in various ways and with the following results. The stations at which only one time is given are included in each solution. Equations 29 and 30 have not been included in the discussion, because the observations were made by projecting the Sun's image on a screen, and therefore considered to be observed under somewhat different conditions from the rest. The residual, however, agrees very closely with the mean result.

Taking the first times given by the observers for contact, but, excluding "suspicion of haze" or "mere atmospheric tremor disturbances," we have the following 30 equations:—

		Residual.
1.	$8{\cdot}122'' = -2{\cdot}571\ \delta\pi + \delta s$	$+0{\cdot}642''$
2.	$7{\cdot}155 = -2{\cdot}571\ \delta\pi + \delta s$	$-0{\cdot}325$
4.	$7{\cdot}006 = -2{\cdot}567\ \delta\pi + \delta s$	$-0{\cdot}474$
8.	$6{\cdot}761 = -2{\cdot}404\ \delta\pi + \delta s$	$-0{\cdot}715$
9.	$5{\cdot}533 = -2{\cdot}297\ \delta\pi + \delta s$	$-1{\cdot}941$
11.	$7{\cdot}739 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}265$
13.	$8{\cdot}119 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}645$
14.	$7{\cdot}888 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}414$
15.	$7{\cdot}893 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}419$
16.	$8{\cdot}833 = -2{\cdot}264\ \delta\pi + \delta s$	$+1{\cdot}360$
17.	$7{\cdot}679 = -1{\cdot}823\ \delta\pi + \delta s$	$+0{\cdot}216$

				Residual.
19.	$7''.769$	$= +0.440\ \delta\pi$	$+\ \delta s$	$+0''.357$
21.	6.689	$= +0.440\ \delta\pi$	$+\ \delta s$	-0.723
24.	7.964	$= +2.212\ \delta\pi$	$+\ \delta s$	$+0.592$
26.	7.169	$= +2.225\ \delta\pi$	$+\ \delta s$	-0.203
31.	5.142	$= +2.225\ \delta\pi$	$+\ \delta s$	-2.230
34.	7.387	$= +2.246\ \delta\pi$	$+\ \delta s$	$+0.016$
36.	6.589	$= +2.248\ \delta\pi$	$+\ \delta s$	-0.782
39.	6.784	$= +2.251\ \delta\pi$	$+\ \delta s$	-0.587
42.	7.069	$= +2.251\ \delta\pi$	$+\ \delta s$	-0.302
44.	7.674	$= +2.254\ \delta\pi$	$+\ \delta s$	$+0.303$
45.	7.270	$= +2.255\ \delta\pi$	$+\ \delta s$	-0.101
48.	7.020	$= +2.256\ \delta\pi$	$+\ \delta s$	-0.351
51.	7.963	$= +2.256\ \delta\pi$	$+\ \delta s$	$+0.592$
52.	7.791	$= +2.256\ \delta\pi$	$+\ \delta s$	$+0.420$
50.	6.434	$= +2.257\ \delta\pi$	$+\ \delta s$	-0.937
53.	8.190	$= +2.570\ \delta\pi$	$+\ \delta s$	$+0.826$
54.	8.517	$= +2.652\ \delta\pi$	$+\ \delta s$	$+1.155$
56.	8.605	$= +2.652\ \delta\pi$	$+\ \delta s$	$+1.243$
57.	7.578	$= +2.705\ \delta\pi$	$+\ \delta s$	$+0.217$

From which we obtain—

$$\delta\pi = -0''.023$$
$$\text{and } \delta s = +7.422.$$

Therefore—

$$\pi = 8''.827 \pm 0''.051.$$

Taking the last times recorded as internal contacts of any kind, we have 30 equations—

				Residual.
1.	$8''.122$	$= -2.571\ \delta\pi$	$+\ \delta s$	$+0''.159$
3.	7.859	$= -2.571\ \delta\pi$	$+\ \delta s$	-0.104
6.	8.541	$= -2.568\ \delta\pi$	$+\ \delta s$	$+0.577$
8.	6.761	$= -2.404\ \delta\pi$	$+\ \delta s$	-1.208
10.	7.556	$= -2.297\ \delta\pi$	$+\ \delta s$	-0.416
12.	8.687	$= -2.295\ \delta\pi$	$+\ \delta s$	$+0.715$
13.	8.119	$= -2.295\ \delta\pi$	$+\ \delta s$	$+0.147$
14.	7.888	$= -2.295\ \delta\pi$	$+\ \delta s$	-0.084
15.	7.893	$= -2.295\ \delta\pi$	$+\ \delta s$	-0.079
16.	8.833	$= -2.264\ \delta\pi$	$+\ \delta s$	$+0.860$
17.	7.679	$= -1.823\ \delta\pi$	$+\ \delta s$	-0.308
20.	8.713	$= +0.443\ \delta\pi$	$+\ \delta s$	$+0.653$
22.	7.398	$= +0.440\ \delta\pi$	$+\ \delta s$	-0.662
25.	8.535	$= +2.211\ \delta\pi$	$+\ \delta s$	$+0.418$
28.	7.965	$= +2.225\ \delta\pi$	$+\ \delta s$	-0.152
33.	9.490	$= +2.222\ \delta\pi$	$+\ \delta s$	$+1.373$
35.	8.165	$= +2.244\ \delta\pi$	$+\ \delta s$	$+0.047$
37.	7.741	$= +2.245\ \delta\pi$	$+\ \delta s$	-0.377
40.	7.257	$= +2.251\ \delta\pi$	$+\ \delta s$	-0.861
43.	7.499	$= +2.251\ \delta\pi$	$+\ \delta s$	-0.619
44.	7.674	$= +2.254\ \delta\pi$	$+\ \delta s$	-0.444
47.	8.621	$= +2.253\ \delta\pi$	$+\ \delta s$	$+0.503$
48.	7.020	$= +2.256\ \delta\pi$	$+\ \delta s$	-1.098
51.	7.963	$= +2.256\ \delta\pi$	$+\ \delta s$	-0.155
52.	7.791	$= +2.256\ \delta\pi$	$+\ \delta s$	-0.327
50.	6.434	$= +2.257\ \delta\pi$	$+\ \delta s$	-1.684
53.	8.190	$= +2.570\ \delta\pi$	$+\ \delta s$	$+0.062$
55.	9.043	$= +2.652\ \delta\pi$	$+\ \delta s$	$+0.912$
56.	8.605	$= +2.652\ \delta\pi$	$+\ \delta s$	$+0.474$
58.	9.831	$= +2.704\ \delta\pi$	$+\ \delta s$	$+1.698$

From which we find—

$$\delta\pi = +0''{\cdot}032$$
$$\text{and } \delta s = +8{\cdot}046.$$

Therefore—

$$\pi = 8''{\cdot}882 \pm 0''{\cdot}045.$$

The probable error upon this assumption is rather less than upon the first, and the difference between the result is not greater than might be expected from the probable error.

Solution on the assumption that the mean of the times recorded for the different kind of contacts by some of the observers would, on the average, best agree with the kind of contact to which the single time records refer.

		Residual.
1.	$8''{\cdot}122 = -2{\cdot}571\ \delta\pi + \delta s$	$+0''{\cdot}386$
2 & 3.	$7{\cdot}507 = -2{\cdot}571\ \delta\pi + \delta s$	$-0{\cdot}229$
4, 5, & 6.	$7{\cdot}789 = -2{\cdot}567\ \delta\pi + \delta s$	$+0{\cdot}053$
8.	$6{\cdot}761 = -2{\cdot}404\ \delta\pi + \delta s$	$-0{\cdot}976$
9 & 10.	$6{\cdot}545 = -2{\cdot}297\ \delta\pi + \delta s$	$-1{\cdot}192$
11 & 12.	$8{\cdot}213 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}476$
13.	$8{\cdot}119 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}382$
14.	$7{\cdot}888 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}151$
15.	$7{\cdot}893 = -2{\cdot}295\ \delta\pi + \delta s$	$+0{\cdot}156$
16.	$8{\cdot}830 = -2{\cdot}264\ \delta\pi + \delta s$	$+1{\cdot}096$
17.	$7{\cdot}679 = -1{\cdot}823\ \delta\pi + \delta s$	$-0{\cdot}060$
19 & 20.	$8{\cdot}241 = +0{\cdot}441\ \delta\pi + \delta s$	$+0{\cdot}491$
22.	$7{\cdot}398 = +0{\cdot}440\ \delta\pi + \delta s$	$-0{\cdot}352$
24 & 25.	$8{\cdot}250 = +2{\cdot}212\ \delta\pi + \delta s$	$+0{\cdot}492$
26, 27, & 28.	$7{\cdot}593 = +2{\cdot}225\ \delta\pi + \delta s$	$-0{\cdot}165$
31, 32, & 33.	$7{\cdot}429 = +2{\cdot}226\ \delta\pi + \delta s$	$-0{\cdot}329$
34 & 35.	$7{\cdot}776 = +2{\cdot}245\ \delta\pi + \delta s$	$+0{\cdot}017$
36 & 37.	$7{\cdot}165 = +2{\cdot}247\ \delta\pi + \delta s$	$-0{\cdot}594$
39 & 40.	$7{\cdot}021 = +2{\cdot}251\ \delta\pi + \delta s$	$-0{\cdot}738$
42 & 43.	$7{\cdot}284 = +2{\cdot}251\ \delta\pi + \delta s$	$-0{\cdot}475$
44.	$7{\cdot}674 = +2{\cdot}254\ \delta\pi + \delta s$	$-0{\cdot}085$
45, 46, & 47.	$7{\cdot}842 = +2{\cdot}254\ \delta\pi + \delta s$	$+0{\cdot}083$
48.	$7{\cdot}020 = +2{\cdot}256\ \delta\pi + \delta s$	$-0{\cdot}739$
50.	$6{\cdot}434 = +2{\cdot}257\ \delta\pi + \delta s$	$-1{\cdot}325$
51.	$7{\cdot}963 = +2{\cdot}256\ \delta\pi + \delta s$	$+0{\cdot}204$
52.	$7{\cdot}791 = +2{\cdot}257\ \delta\pi + \delta s$	$+0{\cdot}032$
53.	$8{\cdot}190 = +2{\cdot}570\ \delta\pi + \delta s$	$+0{\cdot}431$
54 & 55.	$8{\cdot}780 = +2{\cdot}652\ \delta\pi + \delta s$	$+1{\cdot}020$
56.	$8{\cdot}605 = +2{\cdot}652\ \delta\pi + \delta s$	$+0{\cdot}845$
57 & 58.	$8{\cdot}705 = +2{\cdot}705\ \delta\pi + \delta s$	$+0{\cdot}944$

From which we find—

$$\delta\pi = +0''{\cdot}005$$
$$\text{and } \delta s = +7{\cdot}748.$$

Therefore—

$$\pi = 8''{\cdot}855 \pm 0''{\cdot}036.$$

The probable error is smaller than the probable error upon either of the first assumptions, and the result, so far as these observations can fix it, would appear to lie between—

$$\pi = 8''{\cdot}827 \pm 0''{\cdot}051 - 0''{\cdot}068\ \delta\alpha - 0''{\cdot}0099\ d\Delta$$
$$\text{and } \pi = 8{\cdot}855 \pm 0{\cdot}036 - 0{\cdot}068\ \delta\alpha - 0{\cdot}0099\ d\Delta.$$

EGRESS.—RESIDUAL ERRORS from times observed near the EXTERNAL CONTACT.

1.	Barbados - - -	Mr. Talmage - -	$6''{\cdot}902 = -2{\cdot}641\ \delta\pi + \delta s$
2.		Lieut. Thomson -	$7{\cdot}155 = -2{\cdot}641$
3.	Bermuda - - -	Mr. Plummer - -	$5{\cdot}373 = -2{\cdot}592$
4.		Lieut. Neate - -	$4{\cdot}417 = -2{\cdot}592$
5.			$4{\cdot}680 = -2{\cdot}592$
6.	Cambridge, U.S.A. -	Mr. Sawyer - -	$5{\cdot}887 = -2{\cdot}408$
7.	Jamaica - - -	Dr. Copeland - -	$7{\cdot}068 = -2{\cdot}384$
8.		Capt. Mackinlay -	$6{\cdot}445 = -2{\cdot}384$
9.	Jamaica - - -	Dr. Pearson - -	$6{\cdot}403 = -2{\cdot}384$
10.	Kingston, Canada - -	Mr. Williamson -	$7{\cdot}415 = -2{\cdot}301$
11.	Ottawa, Canada - -	Mr. Blake - -	$5{\cdot}226 = -2{\cdot}297$
12.			$6{\cdot}226 = -2{\cdot}297$
13.	Winnipeg, Canada - -	Mr. McLeod - -	$5{\cdot}631 = -1{\cdot}826$
14.	Strait of Magellan - -	Capt. Wharton -	$7{\cdot}334 = +0{\cdot}615$
15.	Bidwill's, New Zealand -	Mr. Marchant - -	$6{\cdot}645 = +2{\cdot}083$
16.		Mr. Hewitt - -	$6{\cdot}174 = +2{\cdot}083$
17.*	Wellington, New Zealand -	Mr. Adams - -	$7{\cdot}353 = +2{\cdot}095$
18.		Mr. McKerrow - -	$7{\cdot}282 = +2{\cdot}095$
19.		Mr. King - -	$5{\cdot}683 = +2{\cdot}098$
20.	Christchurch, New Zealand	Mr. Townsend - -	$7{\cdot}288 = +2{\cdot}117$
21.		Mr. Kitson - -	$6{\cdot}173 = +2{\cdot}120$
22.	Burnham, New Zealand -	Col. Tupman - -	$7{\cdot}642 = +2{\cdot}122$
23.		Lieut. Coke - -	$(9{\cdot}418) = +2{\cdot}119$
24.	Nelson, New Zealand -	Mr. Atkinson - -	$6{\cdot}219 = +2{\cdot}130$
25.			$7{\cdot}104 = +2{\cdot}128$
26.	Dunedin, New Zealand -	Mr. Beverly - -	$7{\cdot}641 = +2{\cdot}128$
27.		Mr. Skey - -	$6{\cdot}882 = +2{\cdot}130$
28.		Mr. Gillies - -	$5{\cdot}908 = +2{\cdot}132$
29.	Auckland, New Zealand -	Capt. Heale - -	$6{\cdot}594 = +2{\cdot}131$
30.	Hobart - - -	Mr. White - -	$7{\cdot}382 = +2{\cdot}496$
31.	Melbourne - - -	Mr. Ellery - -	$6{\cdot}356 = +2{\cdot}595$
32.		Mr. Gilbert - -	$5{\cdot}845 = +2{\cdot}595$
33.	Wentworth, New South Wales.	Mr. Todd - -	$7{\cdot}256 = +2{\cdot}659$

			Residual.
1.	$6''{\cdot}902$	$= -2{\cdot}641\ \delta\pi + \delta s$	$+0''{\cdot}615$
2.	$7{\cdot}155$	$= -2{\cdot}641\ \delta\pi + \delta s$	$+0{\cdot}868$
3.	$5{\cdot}373$	$= -2{\cdot}592\ \delta\pi + \delta s$	$-0{\cdot}919$
4 & 5.	$4{\cdot}548$ (mean)	$= -2{\cdot}592\ \delta\pi + \delta s$	$-1{\cdot}744$
6.	$5{\cdot}887$	$= -2{\cdot}408\ \delta\pi + \delta s$	$-0{\cdot}422$
7.	$7{\cdot}068$	$= -2{\cdot}384\ \delta\pi + \delta s$	$+0{\cdot}757$
8.	$6{\cdot}445$	$= -2{\cdot}384\ \delta\pi + \delta s$	$+0{\cdot}134$
9.	$6{\cdot}403$	$= -2{\cdot}384\ \delta\pi + \delta s$	$+0{\cdot}092$
10.	$7{\cdot}415$	$= -2{\cdot}301\ \delta\pi + \delta s$	$+1{\cdot}096$
12.	$6{\cdot}226$	$= -2{\cdot}297\ \delta\pi + \delta s$	$-0{\cdot}093$
13.	$5{\cdot}631$	$= -1{\cdot}826\ \delta\pi + \delta s$	$-0{\cdot}759$

* Not used; image projected.

				Residual.
14.	$7''{\cdot}334$	=	$+0{\cdot}615\ \delta\pi + \delta s$	$+0''{\cdot}746$
15.	$6{\cdot}645$	=	$+2{\cdot}083\ \delta\pi + \delta s$	$-0{\cdot}078$
16.	$6{\cdot}174$	=	$+2{\cdot}083\ \delta\pi + \delta s$	$-0{\cdot}549$
18.	$7{\cdot}282$	=	$+2{\cdot}095\ \delta\pi + \delta s$	$+0{\cdot}558$
19.	$5{\cdot}683$	=	$+2{\cdot}098\ \delta\pi + \delta s$	$-1{\cdot}041$
20.	$7{\cdot}288$	=	$+2{\cdot}117\ \delta\pi + \delta s$	$+0{\cdot}561$
21.	$6{\cdot}173$	=	$+2{\cdot}120\ \delta\pi + \delta s$	$-0{\cdot}554$
22.	$7{\cdot}642$	=	$+2{\cdot}122\ \delta\pi + \delta s$	$+0{\cdot}915$
24 & 25.	$6{\cdot}661$ (mean)	=	$+2{\cdot}129\ \delta\pi + \delta s$	$-0{\cdot}066$
26.	$7{\cdot}641$	=	$+2{\cdot}128\ \delta\pi + \delta s$	$+0{\cdot}914$
27.	$6{\cdot}882$	=	$+2{\cdot}130\ \delta\pi + \delta s$	$+0{\cdot}154$
28.	$5{\cdot}908$	=	$+2{\cdot}132\ \delta\pi + \delta s$	$-0{\cdot}820$
29.	$6{\cdot}594$	=	$+2{\cdot}131\ \delta\pi + \delta s$	$-0{\cdot}134$
30.	$7{\cdot}382$	=	$+2{\cdot}496\ \delta\pi + \delta s$	$+0{\cdot}621$
31.	$6{\cdot}356$	=	$+2{\cdot}595\ \delta\pi + \delta s$	$-0{\cdot}414$
32.	$5{\cdot}845$	=	$+2{\cdot}595\ \delta\pi + \delta s$	$-0{\cdot}925$
33.	$7{\cdot}256$	=	$+2{\cdot}659\ \delta\pi + \delta s$	$+0{\cdot}479$

Which gives—

$$\delta\pi = +0''{\cdot}092$$
$$\text{and } \delta s = +6{\cdot}531.$$

Therefore—

$$\pi = 8''{\cdot}942 \pm 0''{\cdot}047.$$

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